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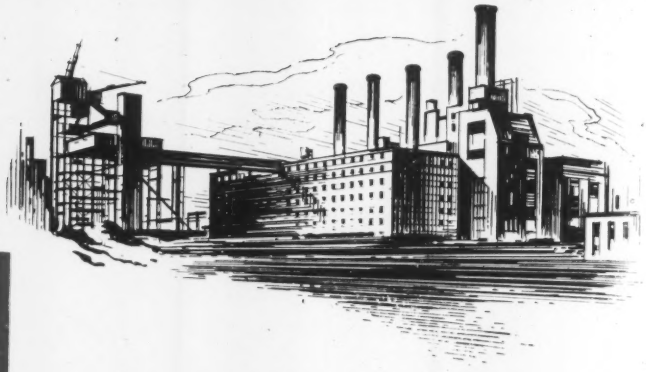
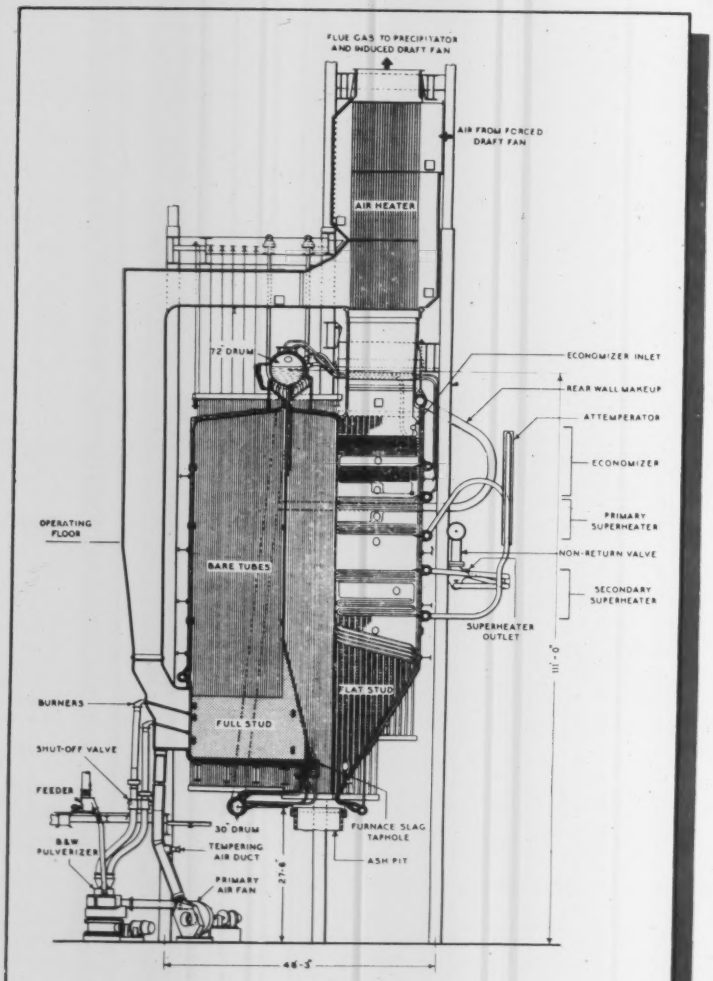
MECHANICAL ENGINEERING

DECEMBER 1945

2 *MORE** MILLION-POUND BOILERS FOR HELL GATE





Two 1,000,000 lb.-per-hr. 900 psi, 950 F B&W Open Pass Boilers of this design are being installed at Hell Gate Station. Each boiler is served by four B&W Type E Pulverizers.

To EXPAND system capacity and improve fuel economy, the Consolidated Edison Company of New York is now installing a 65,000-Kw. topping turbine and two B&W 1,000,000 lb.-per-hour Open Pass Boilers at its Hell Gate Station, world's second largest steam power station.

These boilers are being installed in the floor space formerly occupied by twelve stoker-fired, straight-tube, 275-psi units, and will deliver nearly twice as much steam per hour as the twelve units they replace.

The new steam generators are designed for pulverized-coal firing in slag-tap furnaces. These and other features are shown by the drawing at the left.

This Hell Gate modernization project is another example of boiler selection being strongly influenced by long and satisfactory past experience with the economy and efficiency of B&W equipment. It is patterned after a similar successful topping installation including B&W boilers, at Consolidated Edison's Waterside Station.

---

* Two other million-pound B&W Boilers have been in service in this plant since 1930, tests of which are given in ASME paper presented by W. E. Caldwell, June, 1933, "Characteristics of the Twin-Set Hell Gate Boilers".

Water-Tube Boilers, for Stationary Power Plants, for Marine Service . . . Water-Cooled Furnaces . . . Superheaters . . . Economizers . . . Air Heaters . . . Pulverized-Coal Equipment . . . Chain-Grate Stokers . . . Oil, Gas and Multifuel Burners . . . Seamless and Welded Tubes and Pipe . . . Refractories . . . Process Equipment.

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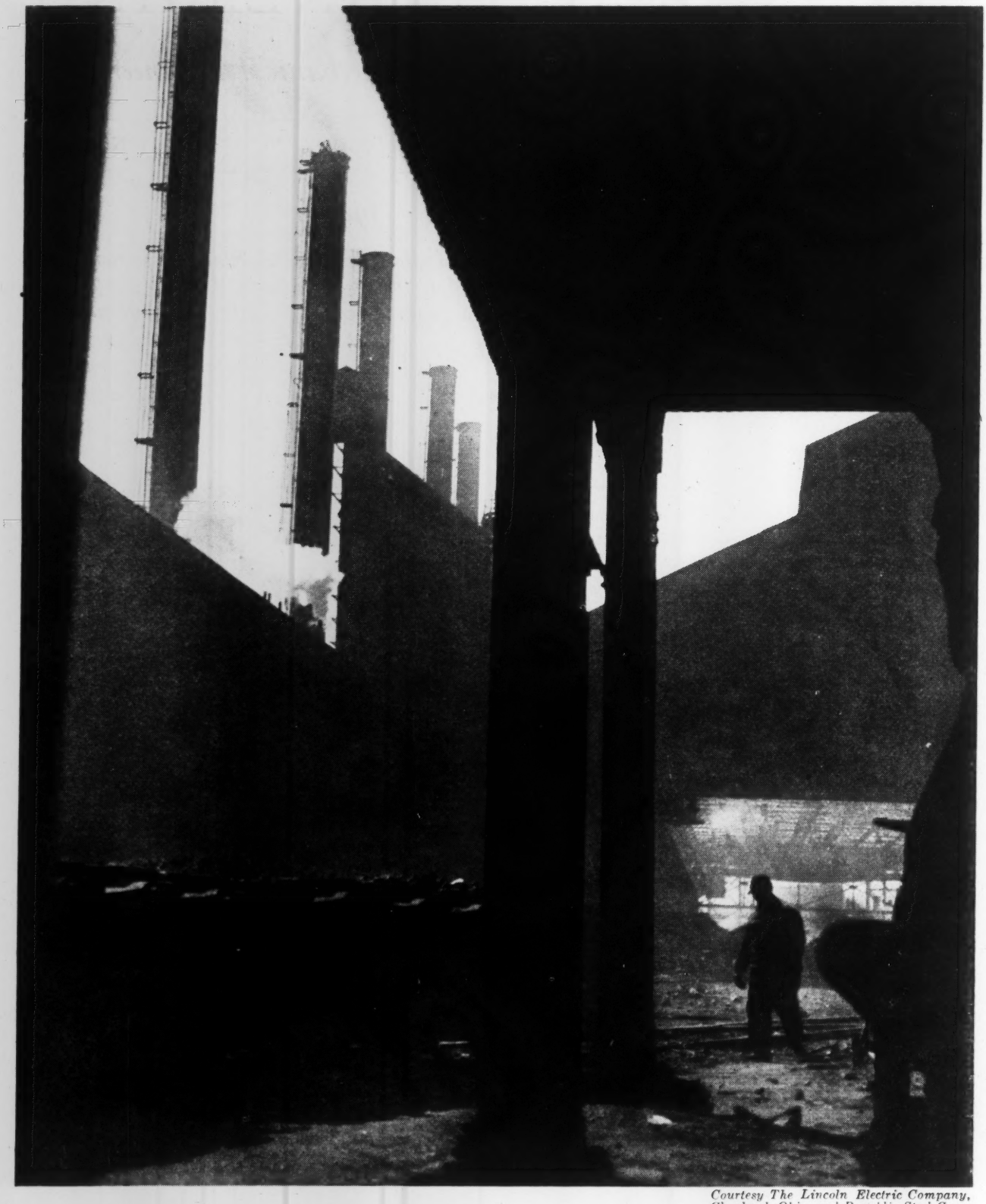

Courtesy The Lincoln Electric Company, Cleveland, Ohio, and Republic Steel Corp.

Arc-Welded Smokestacks

(Replacing those of conventional design, tower over this industrial scene and signify the importance of the electric-arc process in steel-mill maintenance.)

VOLUME 67
NO. 12

MECHANICAL ENGINEERING

DECEMBER
1945

GEORGE A. STETSON, *Editor*

A National Science Foundation

THE summer months of 1945 will long be remembered for three events which occurred almost simultaneously—the ending of the war with Japan, the destruction of two Japanese cities by the atomic bomb, and the release of the report to the President on a program of scientific research by Vannevar Bush, director of O.S.R.D., published under the title "Science, the Endless Frontier." In more ways than one these three events were closely connected; for if the atomic bomb did not end the war, it hastened its end and raised in the minds of the entire world the specter of wars more terrifying than any we have ever experienced with potentialities of destruction beyond our comprehension. The secret of the bomb, at present held by the United States, Great Britain, and Canada, cannot be kept for long because what one group of scientists and engineers has done, another group can also do if given sufficient backing and encouragement. The product of research in the field of nuclear physics which seemed too remote from the daily lives of most of us to be more than an interesting laboratory experiment, the bomb suddenly becomes the most important single factor in contemporary civilization. If a few months ago there were scoffers and disbelievers in the importance of scientific research, few remain today. It is safe to say that the average man today realizes that the United States cannot retain its position as a powerful nation with a high standard of living or adequately safeguard the security of its people unless it also develops and maintains leadership in scientific research. This is the purpose of Dr. Bush's proposal for a National Science Foundation, generously financed and competently administered. This is also the reason for various bills now undergoing hearings which aim to set up such a foundation. As a contribution of the engineering societies to these hearings a statement was prepared by a "panel of appointees" of the Engineers Joint Council, a body composed of the head executives of the American Society of Civil Engineers, the American Institute of Mining and Metallurgical Engineers, The American Society of Mechanical Engineers, the American Institute of Electrical Engineers, and the American Institute of Chemical Engineers. The members of the committee, representing these societies in the order named, were: Boris Bakhmeteff, chairman, Harvey S. Mudd, A. G. Christie, F. Malcolm Farmer, and George Grainger Brown.

The statement, which is too long to be quoted in full, begins by asserting that engineers are vitally interested in basic scientific research because such research is the foundation of modern engineering. The engineering profession, the statement says, stands undivided back of the words of the President that "progress in scientific research and development is an indispensable condition to the future welfare and security of the nation."

Asserting that "war has become a battle of scientists" and that "this country must lead in science to assure national health, prosperity, and welfare," the statement quotes the words of the President to the effect that, "no nation can maintain a position of leadership in the world of today, unless it develops to the full its scientific and technological resources."

Attention is directed to the fact that while "the American people have been foremost in technical ingenuity and industrial organization and in research of 'applied character,'" it is nevertheless well known that "in the realm of basic sciences and basic scientific research the United States did not keep pace with the principal nations of the Old World." To a large extent "practical applied research in the United States relied on basic scientific material coming from overseas." However, the war has violently upset this balance, and "for years to come, the intellectual and scientific realm of the United States will have to depend on its own resources." This means that "the United States must speedily fill the void left open by the ravages of Europe." It becomes self-evident, therefore, that "the size and the urgency of the problem are such that scientific research in this country no longer can be allowed to depend on the course of natural development that prevailed in the past and to rely upon the diminishing funds of private philanthropy. A systematic and generous yearly appropriation of government funds becomes a necessity. Under such circumstances the Engineering Panel joins its voice to the universally endorsed proposal of a National Foundation for promoting and developing basic scientific research."

"The situation indeed bears a resemblance to that at the beginning of the war," the statement continues, "when the country was called upon to build up overnight a war industry capable of meeting the most formidable threat of all times. However, the conversion of our peacetime industry to war was largely a problem of material reorganization, while the present problem of bringing to life and stimulating creative scientific endeavor largely lies in the spiritual and intellectual realm. Indeed, the delicacy of the problem requires the most careful and considerate approach. Methods must be chosen which would assure an optimum and most speedy development. It is equally imperative to abstain from measures which could impair or stultify the sought-for objective."

The statement then presents a number of opinions in respect to finding the best solution of the problem. It is stated that "the primary purpose of the proposed Foundation should be basic scientific research . . . . . The Foundation should not spend government funds for

research in fields which have been obtaining, and will continue to obtain, financial support from other sources." It is the view of the Panel that "basic scientific research necessarily implies fundamental research in the engineering sciences." In its opinion "no useful purpose will be served by extending the scope of the Foundation to embrace 'social sciences.'" The Panel holds with the President that "science can be co-ordinated and encouraged; it cannot be dictated to or regimented. Science cannot progress unless founded on the free intelligence of the scientists. . . . . The Federal Research Agency . . . . should in no way impede that freedom." It is felt that "the director should possess the broadest powers to insure promptness and efficiency" in operations. But in his capacity as chief executive "the director should function under the general control of the board and should be responsible to the latter." The statement further offers opinions on the need for "scholars capable of creative leadership and for adequate staffs of scientifically trained personnel," and observations on sources and training, which, it states, should be in the universities. Additional opinions are offered on the line of demarcation between basic and applied pursuits and the possible duplication of activities which are the "private industry, industrial research laboratories, engineering organizations, and the appropriate federal, state, and municipal agencies." Opinions are also offered on the subject of patents.

The summary of conclusions follows:

1 The development of basic scientific research on a scale commensurate with the dominant position of the U. S. A. is a problem of pressing national necessity. The magnitude and urgency of the task make indispensable government support of such research through a National Research Foundation.

2 Federal funds, administered by the Foundation, should be allocated for purposes where government support is indispensable and should not be diverted to fields where research may rely on other sources. The proposed National Research Foundation should promote basic scientific research only, leaving applications to industrial and technologic practices to the appropriate private, industrial, and public agencies.

3 Basic scientific research should include fundamental research in engineering sciences.

4 Social studies should be the object of a separate agency.

5 The preferable form of organization is to have control of the Foundation vested in a Board appointed solely on the basis of scientific competence, and outside of any partisan or political consideration. The Director of the Foundation should be selected by the Board and be responsible to the latter.

6 The Foundation should be given the broadest authority to enact its own rules and regulations in all matters concerning basic scientific research, in subsidizing the training of future research personnel, and in matters of publication.

7 Engineering science should be recognized in the forming of the Board and the divisional substructure.

8 The Legislative Act establishing the Foundation should be confined to the sole purpose of advancing basic science and should not include controversial legislation dealing with patents.

Moving Day

ON November 14 the editorial and advertising departments of the A.S.M.E. moved into new quarters on the top floor of the building in 39th Street immediately to the west of the Engineering Societies Building. To the normal difficulties which seem to have become the pattern of our postwar living, those of moving were added just as MECHANICAL ENGINEERING was going to press and on top of the preparation of preprints of papers for the 1945 Annual Meeting. If something that was to have been consigned to the wastebasket has turned up in the pages of this issue, the editors will be annoyed but not necessarily astonished. They hope for the best.

The A.S.M.E. is one of the four engineering societies who own the Engineering Societies Building, in which it occupies the eleventh floor, a portion of the twelfth, and, for the last few years, an inadequate suite on the sixth floor—an afterthought in building—where the editorial department has been housed. Recent additions to the staff, made as soon as the end of the war permitted, accentuated the need for more space, and as none could be found in the Society's headquarters, moving into another building proved to be the only way out.

Moving is experienced with mixed feelings The confusion and inconvenience which must be endured are made tolerable by the anticipation of better living conditions, the excitement of new scenes—in this case, a better view of Bryant Park—and the hope that a stimulus may be forthcoming. The familiar dingy walls will be replaced by unfamiliar ones freshly painted. A different arrangement of desks and persons creates a new environment. Decisions are taken to throw out accumulations that need not be moved and were saved in the vain hope that someday they would be useful. But the all-too-human expectation that these outward changes will effect an inward rejuvenation is an escapist's delusion, for wherever a man goes he remains the same man. New scenes soon become accustomed scenes. The inspiration for better work is not derived from external environment. Its strength and vitality come from within.

It is not so much that our outward environment puts its stamp on us as it is that we exert our influence on that environment. Oliver Wendell Holmes wrote about the Professor who broke up his home after twenty years of living in it. "A house is never a home," he wrote, "until we have crusted it with the spoils of a hundred lives besides those of our own past. See what these are and you can tell what the occupant is." And in another vein he commanded his soul to build itself more stately mansions—

"Let each new temple, nobler than the last,
Shut thee from heaven with a dome more vast
Till thou at length art free."

There is nothing temple-like, or noble, or vast about the new editorial quarters, but there is new blood in the staff that inhabits them. It is hoped that this new blood will soon have noticeable effect in improving A.S.M.E. publications, even if it was necessary to move in order to accommodate the young men who are providing it.

ORDNANCE SUPPLY SYSTEM

I—The Army Ordnance Depot Problem

By BRIG. GEN. E. E. MACMORLAND, U.S.A.

DEPUTY CHIEF, FIELD SERVICE, OFFICE OF CHIEF OF ORDNANCE, WASHINGTON, D. C.

The men and women of Ordnance, in uniform or in civilian clothes, may be proud of the part they played in supplying ordnance materiel to the armed forces of the United Nations. There was enough and on time. The supply system of Ordnance involved a large organization to handle over 2,000,000 tons a month. This organization was brought together quickly, the immediate objective being to move the guns and ammunition. Economy was secondary but only in the time element. On V-J Day the supply operations were economical. Accordingly, it is with pride that Ordnance tells the story of its Depot Operations to the engineers of industry in the hope that its large-scale experience may be useful to industry but in the larger expectancy that a critical review of these emergency operations will be useful to those who must operate the ordnance supply problems in the future.

L. H. CAMPBELL, JR.
Lieutenant General, Chief of Ordnance

SINCE the fall of 1941, the Army Service Forces, in supplying the needs of the Army of the United States, has staffed and operated an organization faced with a materials-handling task far exceeding in volume and complexity any previousstorage-and-issue problem. As a major part of the Army Service Forces, the Ordnance Department is deeply involved in this supply problem and in contributing to its solution has developed courses of action that should be of general interest. Accordingly, the four sections of this paper are designed to present in sequence a description of the problem, principles followed in its solution, application of these principles, and results obtained.

That portion of the mission of the Ordnance Department which results in its large materials-handling responsibilities is the procurement, storage, maintenance, and issue to the Army of the United States, of weapons, ammunition, combat and transport vehicles, and spare parts therefor. Because in time of war, procurement of ordnance materiel is almost entirely from private industry, handling problems during manufacture are not covered herein. The balance of the job, comprising problems incident to the handling of the materiel after it leaves the manufacturer and before it is loaded into ships, forms the basis for this series of papers.

THE LOAD HANDLED

The Field Service of the Ordnance Department is assigned the storage-and-issue function. In industrial comparisons, Ordnance Field Service might be likened to both the wholesale and retail functions of a vertically organized concern manufacturing $12,000,000,000 worth of goods annually and distributing in both domestic and foreign markets. As in the case of an industrial concern that manufactures, and stores at a constant rate, an item that has violently fluctuating seasonal sales, Ordnance must receive a regular flow of items from procurement and hold and maintain in storage this materiel preparatory to meeting highly irregular demands of the combat forces. To furnish this regulator in the supply line, Ordnance operates 53 storage depots within the continental limits of the United States.

Although no depot is large enough to carry the "full Ordnance line" of 350,000 items, each of several depots stocks in excess of 100,000 different parts and assemblies and maintains handling facilities that have, under emergency conditions, loaded and delivered over 100 carloads of a single item within 24 hours. Any item may be called for in either wholesale or retail quantities from the smallest spare part for fire-control instruments, where 5000 pieces may weigh no more than $\frac{1}{2}$ oz, to the General Pershing tank weighing 43 tons. These inert items are known as "general supplies." Ammunition also ranges greatly in size, from caliber .22 small-arms ammunition to 4000-lb bombs. Not only is the range of weights of items greater than that normally encountered in private industry, but the average depot must handle both inert and explosive items on a vast scale.

During a recent month, the weight of supplies received into the depots plus those shipped out totaled 1,922,000 tons. In terms of train loads annually, this is more than the equivalent of a train extending from New York to San Francisco and back again. Based on actual hours of depot operations, a carload of material is received and unloaded each minute while another is loaded and dispatched from an Ordnance depot. In terms of carloads, 61,000 cars have been handled in 1 month, and, assuming an average of 10 days for each car, 20,000 carloads of Ordnance supplies were in transit at any one time during that month.

The bulk of the material handled through the depots is received directly from industry with approximately one fourth coming from other sources. Although most of this material arrives in full carloads, a fifth of the cars contain more than one item. Straight cars are routed direct to storage points on the depot, but mixed cars must be opened and the contents sorted for stockage by item. Issue is similar to receipt, in terms of quantities of straight and mixed cars. However, no relationship exists between the mixture of items in incoming and outgoing carloads and, except in rare cases, no need exists for maintaining carload identity in storage.

Nearly all explosive items, which account for 45 per cent of the total tonnage handled, are received and issued with a single stock item in each car. Requisitions placed on the depot for

---

This series of papers was planned and prepared under the direction of Colonel L. J. Meyns, Chief of the Storage Division, Field Service, Office, Chief of Ordnance, by Major Preston D. Carter, Assistant to the Chief of Storage Division, Field Service, Office, Chief of Ordnance. Major Carter was aided in the Section on Packaging by Mr. A. L. Whiton, Chief of the Packaging Branch, Industrial Service; in the Section on Scheduling Depot Operations by Major Ira A. Ruhl, Control Officer, Pueblo Ordnance Depot. The Section on Ordnance Storage Techniques was prepared by Major Warner H. Davis, Control Officer, Letterkenny Ordnance Depot, and Major R. S. Craig, Administrative Officer, General Supply Division, Letterkenny Ordnance Depot.

Contributed by the Materials Handling Division and presented at the Annual Meeting, New York, N. Y., Nov. 26–29, 1945, of THE AMERICAN SOCIETY OF MECHANICAL ENGINEERS.

shipment of this material call for anywhere from 2 to 100 carloads of the same item. On the other hand, general supplies (weapons, vehicles, and parts) may be requisitioned from the depot in quantities such that a thousand items will appear on a single requisition and, when loaded, fill only two or three cars. Expressing each stock item appearing on each requisition as a "line item," a recent month saw 450,000 tons of general supplies shipped in fulfillment of 1,500,000 line items. This was, roughly, 3 line items per ton, but remembering that no vehicle weighs less than 1 ton and may approach 50 tons, the volume of five-and-ten-cent-store business is apparent.

As will be discussed later, every effort is made to compensate for fluctuations in the receiving and shipping load placed on each depot. However, because of ocean-convoy loading sequences, quantity safety limits on rail storage of ammunition, and unpredictable battle-loss replacements, such as those occasioned by last winter's Battle of the Bulge, provision must be made for handling extreme fluctuations. Variance of day-to-day work loads by as much as 500 per cent at one depot during a month is not unknown, and a 100 per cent variation is a routine occurrence. Depots receive advance copies of shipping documents from incoming shipments from 1 to 10 days ahead of the arrival of a car, but occasionally an unannounced car is delivered by the railroad. In the case of ammunition shipments, it is customary to have a minimum of 3 days to load and ship, but emergencies do arise as cited earlier; a longer notice is of little value because of limitations on quantities of ammunition that can be stored on rails, and because explosives are stored packed and ready to ship. Instructions for general-supply shipments vary from a few hours to a month or more, averaging 4 days, and permit of considerable advance packaging and consolidation. However, care must be taken under such conditions that extra handling does not eat up the potential profit of advance planning.

Right here it might be wise to point out that, as Ordnance officers have watched the Army Supply program double and double again in volume, they have kept as a goal the ideal and simplest solution to the depot problem—shipment direct from plant to port. The degree of success obtained is evidenced by the fact that 35 per cent of Ordnance tonnage shipped overseas during the Spring of 1945 by-passed the depots and moved directly to the port. Had this not been done, a maximum month's load on the depot system would have been 2,868,000 tons instead of the 1,922,000 previously cited. During the first 6 months of 1945, this step alone saved the American taxpayer $22,500,000 per year in depot labor costs without regard to transportation charges, dunnage, and congestion on the railroads.

FACILITIES USED

A detailed description of both ammunition and general-supply storage facilities will appear later. Let us note here, however, certain general points concerning the size of the depots. Collectively, the 53 installations cover 285,000 acres, or 450 sq miles, an area equal to one third that of the State of Rhode Island. Depots vary greatly in size from the smallest, at $^1/_{10}$ sq mile, to the largest, which includes 40 sq miles, and provide safe, isolated storage for large quantities of high explosives. There are approximately 15,000 separate covered storage points inclosing a total of 65,000,000 sq ft. In addition, 60,000,000 sq ft of open area have been surfaced for the outdoor storage of both boxed and wheeled items. These storage points are served by 2238 miles of Army-maintained roads as well as 1100 miles of military railroad track. Eighty-five per cent of this area has been acquired during the present emergency; its purchase and the erection of facilities cost the taxpayer $650,000,000, or 1.6 per cent of the value of fighting equipment purchased by Ordnance since the beginning of the present emergency.

PERSONNEL

Although all but six of the depots are operated by the Army (six of them, owned by the Government, have been operated on contract by private industry, in order to compare performance under different types of control), 86 per cent of the 100,000 persons employed at the depot are civilians. Fourteen hundred officers perform most of the key management and supervisory functions. Twenty-two hundred enlisted personnel are assigned to the operation of specialized office equipment for which civilian personnel could not be recruited, and to general training prior to transfer to an overseas depot. Approximately 10,000 prisoners of war and Italian service troops complete the roster of personnel, this group being largely engaged in plant maintenance, salvage, and reclamation activities.

A few of the stations act only in a service capacity, employing fewer than 100 persons handling the products of a manufacturing arsenal or other large installation to which they are attached. The balance, thirty-nine relatively separate installations, vary in personnel from 500 to 6000 each. At these, approximately 50 per cent of the personnel are engaged in storage activities, with the remainder performing stock control, salvage, reclamation, maintenance, and administrative and general-housekeeping functions.

Direction of activities at most depots is under the control of an Army colonel. In general, regular Army officers command the larger installations and reserve officers, the smaller.

Because of the isolated location of most of the depots, problems concerned with the recruitment of personnel are aggravated. Exemptions from draft under Selective Service regulations have been rigidly applied to depot civilians, and retaining young supervisory personnel has been more difficult than in the plants of many contractors engaged in manufacturing Ordnance materiel. Nearly all materials-handling-equipment operators are products of the extensive Ordnance training program and in many cases, some of the most skilled operators are women.

Thirty-five per cent of the depot civilians are women Ordnance workers. This is a slight decrease from a higher percentage reached earlier in the war and the reason for the decline is rather interesting. Early experiments utilizing women in materials-handling in the ammunition area proved quite successful. Accordingly, a drive was instituted for their use on this type of work throughout the country, each crew being supplemented with one or two men to do the heavier jobs. This did not prove as successful as anticipated, however, because it was discovered that regional variation throughout the country in the physical stamina of women was such that in some areas few women could stand this heavy work. The original experiments had been made in a locality where many Balkan and Scandinavian immigrants had settled. Accordingly, in certain areas, a large percentage of the women were retrained for lighter types of work, and normal turnover allowed to reduce the total number of women employed.

The fact that 86 per cent of the total employees are nonmilitary clearly reflects War Department policy of utilizing civilians, wherever possible, in preference to other categories of personnel. Whenever a tight labor area eases, qualified civilians are hired to displace noncivilians from the payroll.

Purely from the point of view of effectiveness of depot operations, it is generally advantageous to replace troops with civilians, even though some training may be required, because troops used are generally available only because they are returned casualties or unable to meet overseas physical qualifica-

tions. On the other hand, prisoners of war and Italian service troops are usually in top physical condition.

There has been almost no unionization of employees in Ordnance depots. However, Civil Service and other government regulations tend to provide not only the advantages of employee representation offered by unions, but also place upon management certain restrictions on freedom of action. In this latter category is the requirement for careful scheduling of daily operations because most employees cannot be sent home on light work-load days. In brief, except for the small percentage of noncivilian personnel, the Army, in its depot operations, is faced with virtually the same personnel problems that confront private industry working under wartime conditions.

EQUIPMENT

Collectively, mechanical equipment used in the handling of materials runs into what only recently would have been considered astronomical figures. In May of this year, there were over 2000 fork-lift trucks in daily use. A third of these, battery operated, were earmarked for the handling of explosives. Although almost each lot of fork-lifts procured during the war incorporated new features, added as a result of past operating experience, the large quantities involved permitted concentration of specific types at certain depots so as to minimize maintenance problems. One feature currently in the process of incorporation is the use of pneumatic-tired equipment found to be more desirable in operations over doorsills and outdoor paved and graveled surfaces. Smoother riding resulting from pneumatic tires not only decreases maintenance costs, but increases safety by decreasing load spillage.

Through the addition of lighter fork-lifts than first used, it is now possible to operate many of the trucks into the railroad car. However, inasmuch as some warehouses are not rail-served, and it has been found uneconomical to operate a fork-lift on a round trip haul of more than 500 ft, 550 warehouse tractors of the variety frequently seen in railroad-station baggage handling are used to haul small trailer trains. In those cases where use of wheeled equipment is not practicable, 53 miles of roller conveyer are available for use.

There are 250 cranes, 60 per cent of which are of a rated capacity of 5 tons or over; also, 190 Diesel-electric locomotives, varying in capacity from 60 to 125 tons, are used for the movement of railroad cars within depot limits. The list of major items of operating equipment is complete with the addition of 7500 motor vehicles, ranging from standard five-passenger sedans used administratively to 15-ton tractor-trailers for use in the hauling of ammunition from rail heads to dispersed storage points.

Maintenance of depot operating equipment is largely performed on the depot under separate policies established for the repair of automotive and materials-handling equipment. Automotive repair is performed on the depot only to the extent of replacing major assemblies. Whenever a teardown and rebuild of a major assembly, or rebuild of entire vehicle, is involved, the equipment is evacuated to one of several Army-operated rebuild or fifth echelon shops located throughout the country. Depots are authorized to perform heavier repair work on materials-handling equipment to the extent of overhaul of major assemblies, such as motors, rear axles, etc. However, for complete rebuild, this equipment must also be evacuated.

Two basic procedures also exist for the performance of preventive maintenance and daily servicing, with several depots operating successfully under each of the plans. It has long been Army policy to charge vehicle operators with responsibility for checking tires, water level, gasoline, batteries, etc., prior to commencing each day's work. Although designed for field operation, this policy has operated satisfactorily in some depots. However, many of the most efficiently operated depots prefer scheduled servicing, by a maintenance crew, either on the job or at an evacuation point during off hours. Advantages derived from use of the latter system include frequent inspection by trained personnel and minimized idle time of labor crews while an attached-equipment operator is away from the job servicing his truck. A disadvantage of the system, however-is the tendency to break the operator-equipment pride relationship. As in the case of all equipment operation, adequate main, tenance and careful operation pay dividends in increased equipment life and decreased lost time resulting from breakdowns.

PLANT MAINTENANCE

The maintenance of the plant proper at each of the depots bears little relationship to the problem generally faced by industry. In order to minimize damage resulting from possible explosion of ammunition, over one half of the installations are located in such isolated areas that complete facilities of a small community must be maintained. Such a depot may include, in addition to administrative and storage buildings, a housing and community center providing all needs for 500 to 3500 persons, complete water-treatment and sewage-disposal facilities, standby power plants, and a complete urban-style fire-fighting force. Complete family shopping facilities, schools, nurseries, and hospital services are also provided at this type of depot.

Slightly less than 50 per cent of all buildings erected since 1940 have been of the "theater of operation" or temporary type, designed for a 5-to-10-year life. Such buildings are of wood construction and will soon approach the age when maintenance costs greatly increase. Although large amounts have already been expended on what is sometimes considered maintenance, work to date has been primarily concerned with modification of standard-design warehouses for the performance of special work, such as bin storage, and packaging and preservation; construction of ramps, car-level docks, rail facilities, etc., in order to promote mechanical handling of supplies; the addition of necessary office space, rest rooms, and heating facilities not originally included in designs because a dead rather than dynamic form of storage was first anticipated. An extensive program of firewall construction, in order to limit exposed areas to 44,000 sq ft, and automatic sprinkler installation have also been inaugurated. Experience has indicated the necessity for such additional fire protection because of irreplaceability of Army supplies in wartime.

A TYPICAL AMMUNITION DEPOT

An Ordnance depot may handle ammunition, general supplies, or both. However, the organization, physical as well as procedural, of a combination depot (one handling both ammunition and general supplies) is such that the storage problem of each of these two classes of supplies realistically may be discussed separately. Accordingly, the term "ammunition depot" should be construed as including the "ammunition portion of a combination depot."

There are twenty-five, or approximately one half of the total, depots actively engaged in the receipt, storage, and issue of explosives. Ammunition is stored in the depot's 700 or 800 igloo magazines, and in its 6 to 15 standard above-ground magazines, or open-storage sites. Also, to conserve storage space built for explosives, small-arms ammunition and inert components are stored in warehouses constructed for general supplies. The three principal types of storage are illustrated in Figs. 1, 2, and 3 and have characteristics as given in Tables 1, 2, and 3.

The rail facilities servicing the ammunition area usually

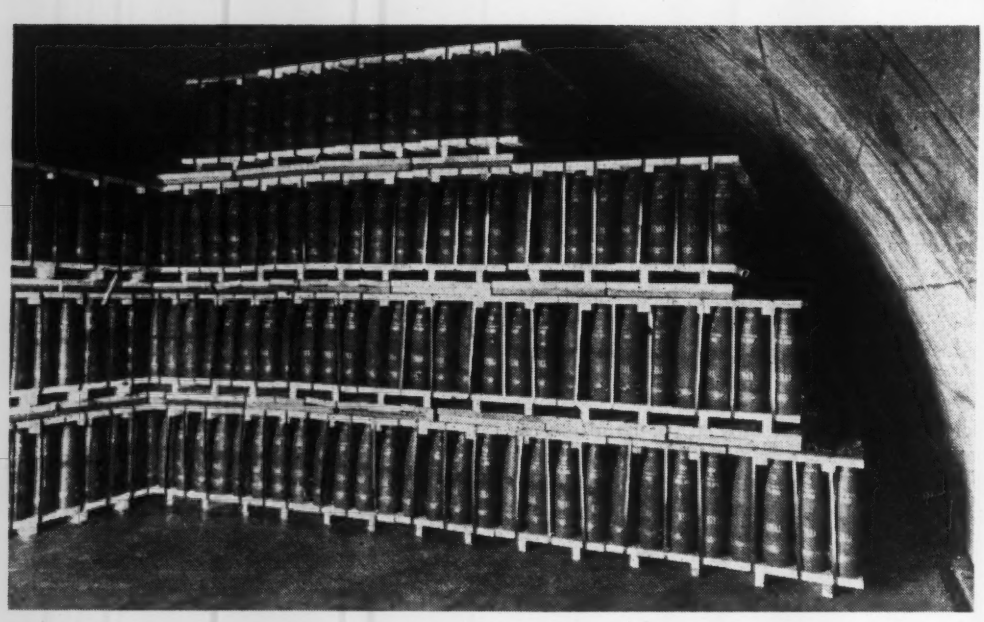

FIG. 1 UNITIZED 155-MM SHELL STORED IN IGLOO MAGAZINE

TABLE 1 CHARACTERISTICS OF IGLOO MAGAZINE (FIG. 1)

Dimensions: 26 ft 6 in. × 60 ft 8 in. (or 80 ft 6 in.) floor; 13 ft 3 in. ceiling
General construction: Reinforced concrete; earth covered; sides arch to form semicircular roof and walls of 13 ft 3 in. radius; 4 ft wide door, one end only; unheated; no power
Maximum storage height: 13 ft
Rail and road service: Less than 1 per cent rail served. Balance served by hard-surfaced road 15 ft in width
Elevation: Ground level; 3 in. doorsill, opening onto 50- to 500-sq-ft concrete apron
Storage capacity: 250,000 lb of explosives

TABLE 2 CHARACTERISTICS OF STANDARD ABOVE-GROUND MAGAZINE (FIG. 2)

Dimensions: 50 × 218 ft floor; 14 ft floor-to-roof truss
General construction: Reinforced-concrete floor; hollow-tile walls; corrugated-sheet-asbestos gable roof; no columns; five 10 ft-wide doors equally spaced on one side; unheated; no power
Maximum storage height: 17 ft
Rail and road service: 100 per cent rail and hard-surfaced road, served one side
Elevation: Car-door level; 10 ft wide concrete loading platform full length of building
Capacity: 500,000 lb of explosives

include a 200-car-capacity inspection and classification yard and a 15- to 20-mile closed loop of track through the area. Ten to twenty, two-car capacity loading points are regularly spaced throughout the area on spurs or passing tracks. At some depots, improved handling methods have justified expansion of docks to three-car capacity, thus decreasing frequency of car-spotting. These points, where ammunition is transferred between boxcar and truck, may be hard-surfaced ground-level areas, approximately 200 × 40 ft; car-door-level concrete 10 × 60 ft docks, with ramps; or similar docks 20 ft wide.

In the parlance of the ammunition handler, rail service to the door of the storage point results in "direct" handling. Where explosives must be moved by truck or semitrailer, from rail to storage point, "indirect" handling is involved. The length of indirect hauls (60 per cent of ammunition is so handled) varies from 800 ft to 5 miles, the latter distance being involved when a rush shipment requires the simultaneous use of several loading points for a commodity stored in a limited area. Elimination of indirect handling, by furnishing rail service to each storage point, would have greatly reduced handling costs but, when the depots were constructed, sufficient steel was not available to lay the 2500 miles of track required. Accordingly, direct handling at all storage points is possible only at some of the prewar installations.

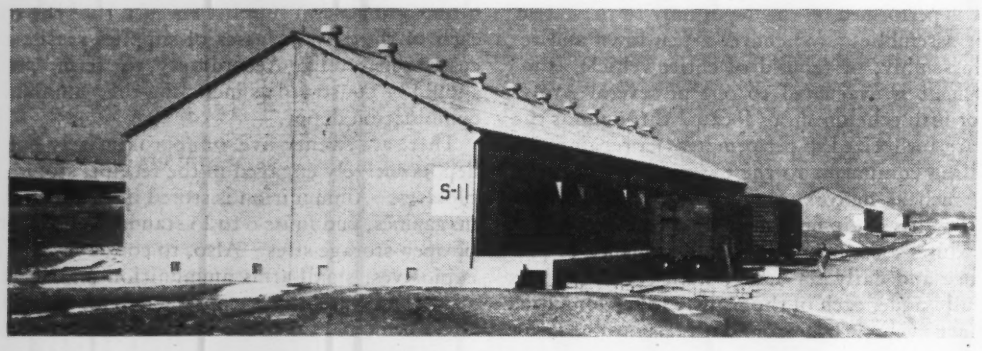

FIG. 2 EXTERIOR VIEW OF STANDARD ABOVE-GROUND MAGAZINE

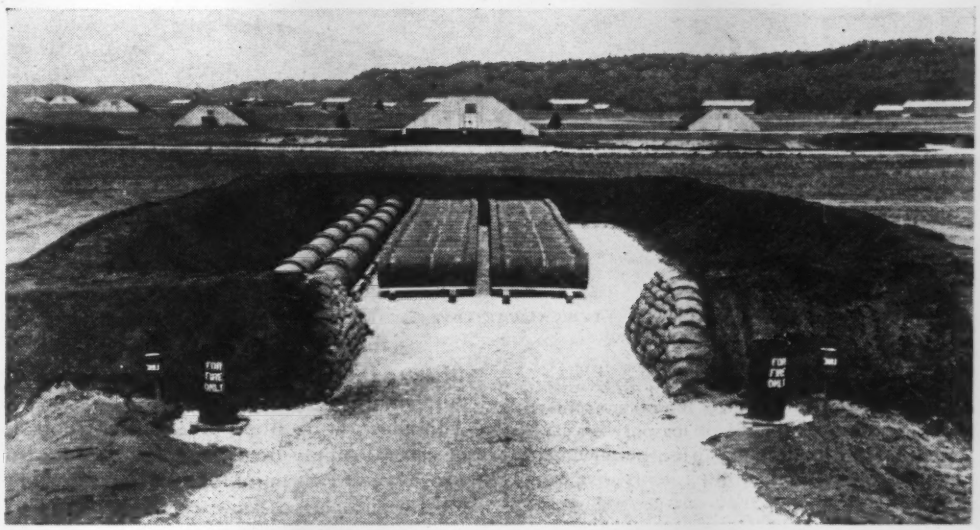

FIG. 3 OPEN STORAGE OF 4000-LB BOMBS

TABLE 3 CHARACTERISTICS OF OPEN-STORAGE SITE (FIG. 3)

Dimensions: Minimum of 10 and maximum of 36 sq ft per ton of explosive stored
General construction: Rectangular; level ground; maximum surfacing of light gravel; 5-to-6-ft-high surrounding earth barricade with 16-ft truck opening; no power
Maximum storage height: 6 ft
Rail and road service: 10-to-15-ft-wide hard-surfaced or dirt road
Elevation: Ground level
Storage capacity: 100,000 lb of explosives, minimum; 500,000 lb, maximum

The typical depot handles 1000 carloads per month roughly, equally divided between receipts and shipments, with quantities of a single item only in each car. Handling characteristics of the materiel as unloaded, or loaded, fall into five general classifications, Table 4.

TABLE 4 AMMUNITION-HANDLING CHARACTERISTICS (AS RECEIVED AND SHIPPED)

Handling unit	Items	Typical dimensions	Weight range, lb
Boxes	Small-arms ammunition, antiaircraft ammunition, fuzes, grenades, flares, mines	32″ × 14″ × 10″	50–120
Crates and miscellaneous unboxed, inert	Bomb fins, practice bombs	24″ × 15″ × 15″	20–60
Pallet loads	Projectiles 6 in. diam and up	27″ × 24″ × 12″	750–850
Small cylinders	Comp. round 2½″–4″ diam, powder	30″ × 5″ diam (min)	25–70
Bombs	Bombs	48″ × 15″ diam (min)	250
		118″ × 39″ diam (min)	4000

The manufacture, test, storage, issue, and use of ammunition is controlled by original manufacturer's lot number. The necessity for such control during test at time of army acceptance is apparent, because even existing rigid specifications permit of slight variations between lots, resulting in different firing characteristics and, because deterioration in storage is not yet completely predictable, lot control throughout the life of ammunition is equally necessary. Sizes of lots that must be fully identified while on the depot range from slightly less than one railroad carload for some items, to three or four carloads for others. While this is only a nuisance at time of receipt, it develops into a serious problem as shipments leave lot "tag ends" scattered throughout the igloos; this in spite of the fact that shipping orders permit of a small variation from quantity ordered so as to minimize such conditions.

In most instances, ammunition is shipped in the containers in which received and, under war conditions, an ammunition depot, accordingly, does little but actually receive and ship. Secondary work is primarily limited to reclamation of incoming dunnage; prefabrication of storage dunnage; consolidation of lot "tag ends;" and repair or modification of ammunition in storage. Because of the wide daily fluctuations in receipt and shipment demands (although an average day is 40 cars, it is an unusual month that does not several times demand up to 75 cars per day and as few as 15 at other times), the scheduling of each day's work must be performed on a daily basis to insure that, when loading or unloading is slack, maximum utilization of receiving and shipping labor is obtained as secondary work. A more nearly ideal solution would be a leveling of the daily volume of receipts and shipments, but any appreciable improvement in this direction is blocked by two conditions; (1) limits on quantities of explosives that may be stored on rails; and (2) wartime shortage of box cars.

A TYPICAL GENERAL-SUPPLY DEPOT

The general-supply portion of a depot storing both ammunition and general supplies and a depot handling only general supplies are considered as "general-supply depots." Ordnance has 48 installations in this category. From the viewpoint of organization and materials-handling problems, a depot may be either a "storage" depot or a "master," "filler," or "distribution" depot.

Storage depots handle items only in bulk quantities with materiel stored in warehouses, in sheds, or in the open. Less standardization of design exists in general-supply buildings than in the case of ammunition storage points; however, typical conditions at a World War II type of installation are pictured in Figs. 4, 5, and 6 and have the characteristics given in Tables 5, 6, and 7.

The storage depot handles a large portion of its materials in carload quantities and, except in unusual circumstances, re-

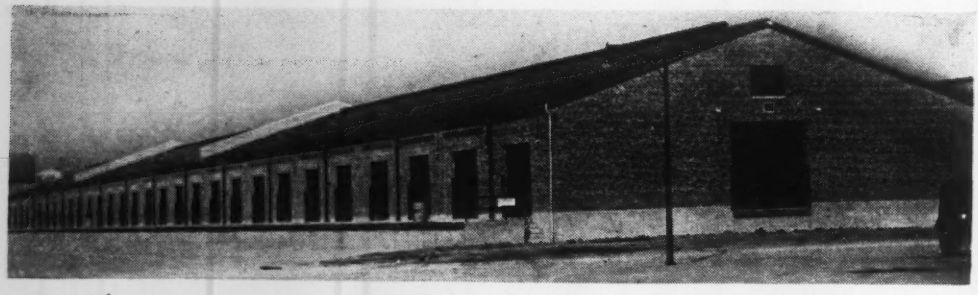

FIG. 4 TYPICAL CAR-LEVEL WAREHOUSE

TABLE 5 CHARACTERISTICS OF WAREHOUSES (FIG. 4)

Dimensions: 180 ft × 500 ft floor; 14 ft–16 ft floor-to-roof truss
General construction: Concrete floor; frame or masonry walls; flat wood truss roof, pitched; 16-ft bays, 60-ft aisles; minimum 10 ft wide × 12 ft high sliding or overhead rolling doors, five equally spaced on each side, one centered each end; one or two transverse fire walls with center door; unheated; electric lights
Maximum storage height: 18–20 ft
Rail and road service: Hard-surfaced roads and entrances to all doors; outside, rail service, one side
Elevation: Ground or car-door level (ground-level warehouses were originally designed for shed storage of wheeled vehicles and artillery but were converted to general warehouses by addition of sides and concrete floors); car-door level have 10-ft wide concrete loading platforms full length each side; 10-deg slope outside ramp at each end door
Items stored: Spare parts, boxed or unboxed; cleaning and preserving materials; target materials; optical equipment; tires; batteries; small arms

ceives and ships items in the original container. Accordingly, as in the case of ammunition depots, it offers an excellent opportunity for the application of materials-handling equipment, such as fork-lift trucks, pallet jacks, and warehouse trailers. Specific handling techniques developed will be discussed in a later section of this paper. It may be pointed out here merely that problems faced in operation of these depots are closely allied to those at a canning-company warehouse or a paper-mill pulp-storage point.

In addition to filling orders from troops for large quantities of general-supply items, a storage depot also acts as a back-up or reserve storage point for a master, filler, or distribution depot. Operation of depots in each of these latter three categories is similar, the distinction largely lying in stock levels maintained and type of customers served. Identical items are stocked in several depots throughout the country. For each item, however, one depot is designated as responsible for maintaining reserve stocks, and issues these only as a last resort. Such depots are designated as "masters" and may issue in either bulk or retail quantities to fill either overseas or domestic demands. "Filler" depots are responsible for overseas supply in wholesale

TABLE 6 CHARACTERISTICS OF STORAGE SHEDS (FIG. 5)

Dimensions: Various, 100,000–200,000 sq ft floor; 14–16 ft ground-to-roof truss
General construction: Earth floor; top curtain walls to base of truss; flat wood truss roof, pitched; 16-ft bays, 60-ft aisles; unheated; no power
Maximum storage height: 18–20 ft
Rail and road service: Hard-surfaced road only
Elevation: Ground level
Items stored: Wheeled vehicles and artillery; export-packed spare parts

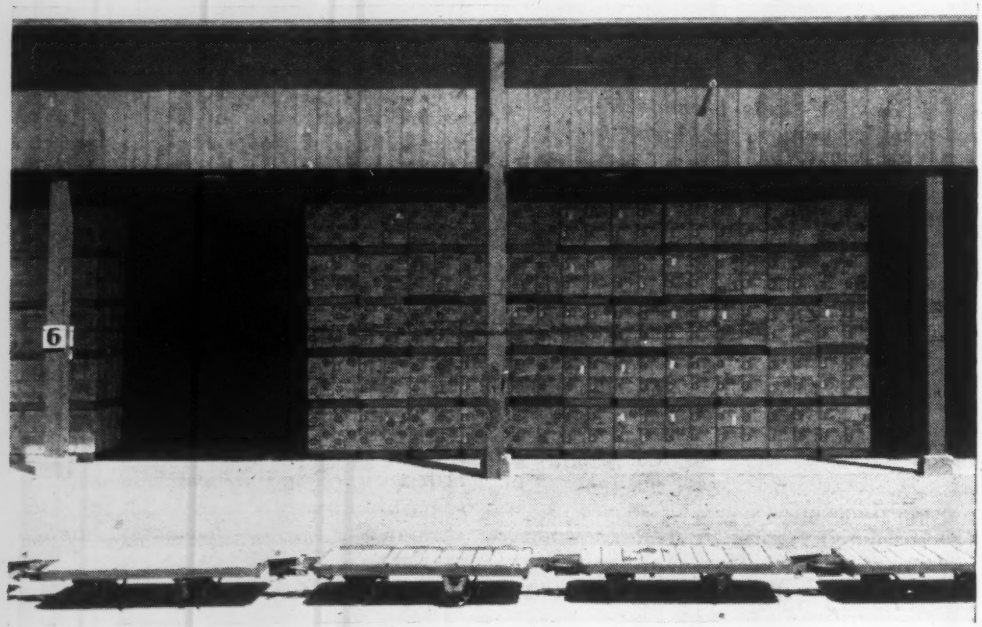

FIG. 5 SHED STORAGE UTILIZED ON WEST COAST

FIG. 6 OPEN STORAGE OF VEHICLES, BOTH WHEELED AND BOXED

TABLE 7 CHARACTERISTICS OF OPEN HARDSTANDING (FIG. 6)

Dimensions: Areas of 100,000–1,000,000 sq ft
General construction: Various; compacted gravel; water-bound macadam; concrete; combination (concrete aisles serving gravel storage areas); open drainage except at aisles; no electric power
Rail and road service: Hard-surfaced road; rail service with ramped car-level loading dock 25 × 500 ft, located within a maximum of 500 yd of the areas
Elevation: Ground level
Items stored: Wheeled and track-laying vehicles; artillery; export-boxed spare parts

and retail quantities, and consolidate orders prior to movement to port. "Distribution" depots perform a similar function for troops in training in the United States.

Although master, filler, and distribution depots handle some bulk items, they are primarily designed to fill requisitions calling for retail quantities. Accordingly, warehouses are modified by the addition of heating and lavatory facilities, office space, and more lighting to provide for bin operations and packing lines. However, because a large percentage of the master, filler, and distribution depots are prewar Army installations, only a portion of the warehouses are of this modified semi-standard design. No two of these installations are identical, either as to mission or facilities. In several cases it has been necessary to utilize for storage purposes multistoried buildings, some of which are old Army buildings, and others leased for the duration of the present emergency. As in the case of storage depots, between ten and fifty storage buildings are involved on an area ranging from 100 to 500 acres.

In addition to the storage function, many master, filler, and distribution depots operate large fifth echelon shops where battle-torn equipment and materiel damaged in training are returned for complete rebuild. Depot-storage personnel are not responsible for the thousand or more mechanics working in these shops. However, the storage officer does look to them for assistance in the preservation of materiel in storage, and he helps shop operations by receiving and shipping the materiel on which they work.

One half the general-supply tonnage, in the Ordnance system as a whole, is handled through open storage, while 6 per cent passes through bins, and the balance is stored, as bulk items in warehouses and sheds. Virtually no bulk fluids or raw materials are handled, but otherwise almost every size, density, and weight of handling unit is encountered up to 45 tons. Handling-unit characteristics, by type of storage, may be grouped as indicated in Table 8.

TABLE 8 GENERAL-SUPPLY-HANDLING CHARACTERISTICS, AS STORED

Type of storage	Handling-unit weight ranges, lb			
	Box and crate	Pallet loads	Unboxed	Wheeled
Bin and reserve (box or rack)	10–200	200–2000	0.001–50	.....
Bulk warehouse	25–10000	100–6000	25– 10000	.....
Shed	25–10000	1000–6000	25– 10000	500–15000
Open	25–10000	1000–6000	25–180000	500–90000

It was indicated previously that the operation of a general-supply "storage" depot is similar to that of an ammunition depot. This applies not only to the fact that, in both cases, receipts and shipments are in bulk quantities but also to the ability to ship material in the same containers in which received and stored. Again, as in the case of ammunition depots, general-supply storage depots among themselves are relatively the same size and have essentially the same shipment-time demands placed upon them. The only major difference that exists between various installations in this category is that one may specialize in automotive materiel while another may handle primarily artillery and other items of "shooting ordnance;" others have various combinations of this extreme difference in stockage.

FIG. 7 ORDNANCE SUPPLIES MUST BE PACKAGED TO MEET SEVERE OVERSEAS HANDLING CONDITIONS—FRANCE, 1944

Not only do general-supply master, filler, and distribution depots as a group differ from storage depots, but each of the depots within this group differs considerably from other master, filler, and distribution depots. Sizes of independent installations range from 450 to 3500 persons; no two depots handle exactly the same range of items, but all of them have a common difference from storage depots in that nearly every item must be specially selected from stock and packed for shipment; no typical depot load exists; ranges of monthly receipts and shipments run from 4000 to 65,000 tons each.

The smallest depot receives a minimum of 2000 and the largest, a maximum of 40,000 tons per month. A part, or all, of this materiel may come directly from procurement or reclamation centers (where used materiel is rebuilt and returned to supply channels in condition similar to shipments direct from procurement) and usually arrives at the depot packed with several items to each railroad car. Except for such items as vehicles and artillery, which can be moved immediately to open storage, boxes must be unloaded from the car, checked for conformity with latest marking instructions, and re-marked where necessary, prior to storage. Boxes containing several items must be opened and the items sorted prior to being placed in bin or reserve stock.

Up to 40 per cent (average 25 per cent) of a master, filler, or distribution depot's receipts may be materiel returned directly from the using troops or stocks at Army Ground Force or Army Air Force posts, camps, and stations. This materiel may be returned in either usable or unusable condition but in any event, it requires complete sorting, inspection, and repacking prior to being placed in stock. In order to avoid mixing any of these returns, prior to reworking, with materiel immediately available for issue, separate receiving departments are usually maintained. During the past 12 months, efforts to reduce stocks in the hands of troops at posts, camps, and stations have resulted in the reclamation of 20,000,000 lb per month. Valued at $1 per lb, this material has been reclaimed, for reissue and corresponding reduction of procurement demands, at the rate of a $250,000,000 per year. This does not include salvage activities carried on at the depots which have resulted in the recovery of scrap materials averaging $2,500,000 per month for the past 18 months in brass alone.

Tonnage ranges just shown for receipts are also true of shipments. In the Spring of 1945, 40 per cent of this shipped tonnage was directed to domestic destinations. Goods required to fill such "zone of interior" requisitions are selected from depot stocks and packed into 50- to 70-lb boxes, or, in the case of tank tracks, springs, vehicles, etc., loaded unpacked. Filling time for domestic requisitions averages from 7 to 14 days, although some shipments have a 90-day advance notice, and other requisitions require immediate filling because Fort Blank has sent a truck convoy to the depot with requisition in hand.

An average of 60 per cent of shipments is directed toward overseas destinations, but individual depots may have any possible combination of overseas and domestic shipments. A filler depot may have as much as 30 days to select and pack, prior to movement to port, in fulfillment of an overseas requisition. On the other hand, it may have a maximum of 4 hr to perform the same work and move small quantities to the nearest airport for loading on a plane that will deliver the goods to the hands of combat troops 24 hr later. Average conditions provide 3 to 7 days for the performance of this work.

PACKAGING FOR SHIPMENT

Packaging materiel for global war presents one of the greatest problems of the entire Army supply program. Raw material, man-hours, and critical shipping space are completely wasted unless the materiel is properly protected to withstand the handling and storage conditions that will be encountered in the long journey to the combat zones.

Materiel is subjected to adverse conditions almost the moment it leaves the manufacturer's plant. Ships leaving this country are loaded to capacity. In fact, many large items such as trucks, tanks, guns, etc., are loaded on the decks of practically every ship that leaves the ports of embarkation, and such equipment is subjected to salt spray during the entire voyage. The effect of the spray or salt-laden air on materiel is well known; unless the critical operating surfaces of the

equipment are thoroughly protected, complete overhaul and substantial replacement of parts will be necessary before the equipment can go into action.

The salt-spray hazard, however, is only a small portion of the story. The unloading hazards at ports of debarkation or "over the beaches;" the days, weeks, or even months of outdoor storage in the theaters of operations; and the many handlings by inexperienced personnel must also be considered.

Handling conditions at all ports of debarkation are extremely severe. The lack of modern handling equipment, the native labor employed, and the necessity for speed in discharging cargo present hazards that are peculiar to wartime shipments.

The invasions of Africa, Sicily, Italy, and France, and the war in the Pacific necessitated the unloading of a high percentage of materiel over the beaches where no equipment other than the ship's tackle was available. In such operations, small boxes were loaded into rope nets and lowered over the side of the ship into DUKW's which took them ashore to the sorting areas. These rope nets, or slings, exert tremendous crushing action on the boxes, and improperly designed containers will invariably fail. When the nets are set on the ground in the sorting areas, the customary way of emptying the net is to lift one end with a crane, and the boxes tumble to the ground, frequently from a height of 7 or 8 ft (see Fig. 7).

In beach operations, heavy equipment is lowered to landing barges by means of cable slings. When the barges reach shore, the equipment is either lifted with tractor cranes or dragged to the beaches with bulldozers. This subjects the heavy crates to enormous strains and stresses and, if diagonal braces are omitted or improperly applied, or if any other members of the crates are undersize or of inferior quality, the crates will be unfit for additional handling and subsequent, necessary, high stacking.

Mechanical equipment, such as used in the depots throughout the country, is either not available in the theaters or cannot be used because of the condition of the terrain where the smaller boxes are stored. Tractor cranes are generally available for lifting the heavier crates, but the lighter packages must be manhandled from the time they leave the ports of debarkation until they reach the combat forces.

Soon after we entered the war, insistent reports came from overseas asking for packages that could be carried and stacked by one man; as a result, the Ordnance Department set a maximum load limit of 70 lb wherever possible. It has been found that the "one-man package" has greatly accelerated unloading of cargo and materially reduced handling time throughout the entire supply line. The lightweight boxes will withstand all of the abuse to which they are subjected and can be moved with ease and speed. Both of these qualities are important requisites of a mobile war.

Indoor storage in active theaters is practically nonexistent. Any orchard, pasture, or fairly level piece of ground may become a depot and frequently the bottom tier of boxes forms a platform that keeps the others out of the mud. Boxes may remain in these depots for many months, exposed to heavy rainfall, high humidity, and the extreme heat of a tropical sun. The only protection afforded the materiel is that which was provided in the manufacturer's plant or in the depot that did the original packing.

This completes an over-all picture of the storage-and-issue problem faced by the Ordnance Department and a description of the facilities used in its solution, prior to July 1, 1945. For security reasons, however, all figures pertaining to storage capacities and volumes of receipts and shipments depict conditions existing prior to the defeat of Germany. Also, in certain cases, actual conditions have been simplified in description both for security reasons and for purposes of clarifying major problems. Where possible, the effect of such complicating factors will be discussed in subsequent sections dealing with management techniques developed by Ordnance and applied to the solution of the general problem set forth herein.

LAIANA BEACH, NEW GUINEA, AUGUST, 1943

Loosening by Vibration of THREADED FASTENINGS

By J. N. GOODIER[1] and R. J. SWEENEY[2]

IT is common experience that nuts and other threaded fasteners can be loosened by vibration even though they are initially tight. In spite of the damage and annoyance caused by such failures, and in spite of numerous efforts to prevent them, the mechanism of the loosening process has remained obscure. It is true that sometimes it is rather obvious, as when the bolted parts are rotated about the bolt in scissors or pliers. The surface on which the nut (or bolt head) bears may have friction enough for the unscrewing torque but may slip when trying to apply the larger screwing-up torque. Again, the bolted parts may wear or squeeze down especially when the surfaces are rough or burred. Loosening in these cases may be attributed to poor design or workmanship.

The fact that loosening, not attributable to obvious causes, occurs very commonly suggests that it is almost normal behavior for a nut to unscrew during vibration. The authors, starting from the idea that loosening would be a consequence of mere fluctuation, not necessarily rapid, of bolt tension, formed a theory of the mechanism of loosening and carried out an experimental investigation of it in ordinary tensile-test machines. The result is a demonstration that loosening is produced by simple fluctuation of tension in such machines, and substantial confirmation of the theory.

A THEORY OF THE LOOSENING PROCESS

When a bolt (with nut) is loaded in tension, the diameter contracts elastically according to Poisson's ratio. The nut, at least the active part of it, expands because it is compressed against its seat, and because the thread pressures have outward radial components and are not applied at mid-thickness in the cylinder wall.[3] During any increase of load, therefore, the bolt thread is moving radially inward and the nut thread radially outward. The direction of the frictional forces will be that of the relative motion, that is, radial if there is no circumferential motion. The same is true of the base friction. But the nut cannot remain in equilibrium if the friction is radial. Circumferential friction is required to counteract the loosening torque of the normal components of thread pressure. While the load is changing, therefore, the nut and bolt act as a reversible screw mechanism. The pull in the bolt causes rotation of the nut. Of course any such rotation means that the relative thread motion is no longer exactly radial.

The analysis which follows shows that the mechanism can remain reversible even when the relative motion deviates from the radial direction, that is, the rotational displacement may be comparable with the elastic radial expansion of the nut, although it must remain relatively small. Of course if it is large, it brings the friction close to the circumferential direction again in spite of the radial motion, and the mechanism ceases to be reversible. It will require an external loosening torque to produce the large rotation. The amount of spontaneous loosening rotation accompanying any change of load is thus governed by the radial elastic expansion of the nut, together with of course the elastic contraction of bolt diameter.

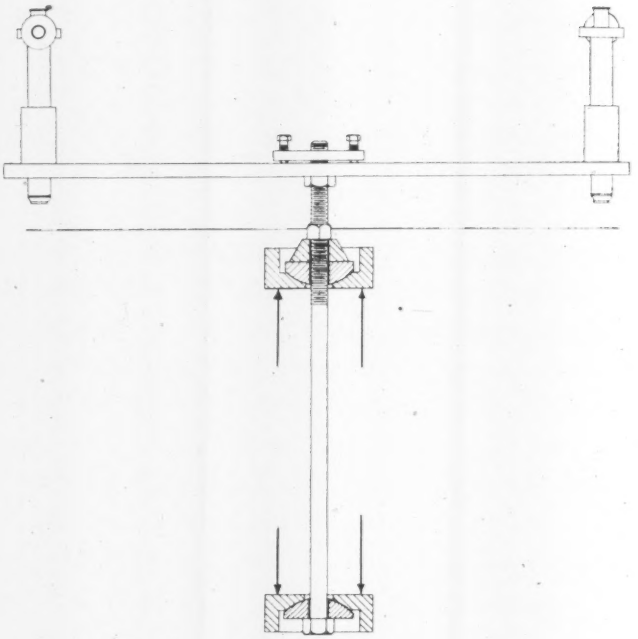

FIG. 1 TEST EQUIPMENT

EXPERIMENTS

A set of nuts and bolts (3/4 in-10 N.C. American Standard Regular, C-1137 Cold Drawn Steel) was repeatedly loaded and (nearly) unloaded in tensile-test machines, with means for measuring small rotations of nut relative to bolt. The arrangement is shown in Fig. 1. Two pointers were fixed in the nut, diametrically opposite. A rigid arm, fastened to the bolt projecting above the nut, carries a measuring microscope at each end, focused on the nut pointers. A reading is thus obtained when the nut rotates on the bolt or when the bolt turns within the nut. Fig. 2 shows the angular position of the nut versus number of loading-unloading cycles, performed manually on three different tensile-test machines. The expected loosening of the nut is found, in one case to the extent of 5.5×10^{-3} revolutions in 500 cycles. This is equivalent to a relaxation of 73 per cent of the maximum bolt tension (6000 lb) on a bolt length of 1 in., proportionately less on longer lengths. The amount of creep is different in different machines and was also found to be different from specimen to specimen in the same machine.

The nut bases were ground square, and the bolt threads were Class 3. A new nut and an unused section of bolt thread were used in each test.

In all tests a small net loosening rotation of the nut occurred in each loading cycle, with rare exceptions. The creep indicated by the curves in Fig. 2 represents of course the accumulation from the individual cycles. The amount in a cycle was not uniform. It was always large at the beginning of a test and showed a tendency to diminish, then increase suddenly,

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[2] Director of Research, Stover Lock Nut and Machinery Corporation, Easton, Pa. Mem. A.S.M.E.

[3] "The Distribution of Load on the Threads of Screws," by J. N. Goodier, *Journal of Applied Mechanics*, Trans. A.S.M.E., vol. 62, 1940, p. A-10.

then diminish again, and so on repeatedly. Any pause, such as leaving the bolt under some load for an hour or two, almost always led to larger creep per cycle as soon as the test was resumed.

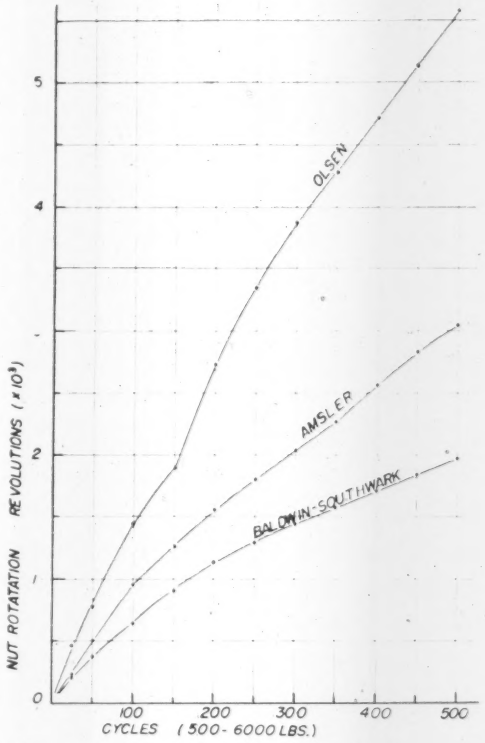

FIG. 2 ROTATIONAL CREEP OF NUT IN REPEATED LOADING IN THREE TESTING MACHINES

Readings were taken from time to time of the rotation occurring within individual cycles. Some of these are shown in Fig. 3. They show the small residual creep in each cycle, but also show that there is a considerably larger loosening rotation during loading, most of which is recovered on unloading. This recovery, i.e., a tightening rotation during unloading, is puzzling if we attribute the microscope readings simply to rotation of the nut, because the net torque on the nut could never be in the tightening sense. It consists of two parts; a "normal pressure torque" due to the normal components of thread pressure, always in the loosening sense, and a "friction torque" which will either counteract the normal pressure torque or be overcome by it. Nevertheless the observed tightening rotation during unloading is to be expected on the theory proposed, as will appear.

DEVELOPMENT OF THE THEORY

Let us suppose that the lower (remote from the nut) end of the bolt does not rotate, and also, temporarily, that its upper end and the nut do not rotate. Then the friction forces during both loading and unloading are radial, not circumferential. There is normal pressure torque on the nut and the equal and opposite normal pressure torque on the bolt. The bolt within the nut tends to rotate, by elastic twisting of the whole bolt length, and the nut tends to turn the other way; each of course in the direction of loosening.

We took the top of the bolt, and the nut, as prevented from rotating so as to be able to say that the friction would be radial. Suppose now that there is some relative rotation during the loading cycle, but so little that the relative velocity of the threads, and hence the resultant friction force, is still nearly radial, and the friction torque on the thread consequently insufficient to counterbalance the normal pressure torque. Then the unbalanced part of the normal pressure torque twists the bolt against its fixed lower end, the rotation within the nut being in the loosening sense. The reaction to the unbalanced torque acts of course on the nut, also in the loosening sense. It may or may not be sufficient to overcome the base friction (also nearly radial) and so cause slip. During unloading the unbalanced torque on the bolt is gradually reduced and the elastic twist diminishes. Thus, if the nut does not slip, this reduction of bolt twist, involving a tightening-up rotation of the bolt within the nut, will be observed in the microscope as a relative rotation in the tightening sense. If the nut slips by a rotation in the loosening sense smaller than the elastic rotation of the bolt, the difference will appear in the microscope as a tightening rotation during unloading. This corresponds to what is observed in Fig. 3.

Considering now what would occur during a cycle, we should have, during loading, a gradual twisting of the bolt (in the loosening sense) within the nut, caused by the normal pressure torque on the bolt opposed by the smaller torque of the circumferential component of friction. This proceeds steadily up to maximum load. When the load begins to diminish, the bolt tends to twist back and the friction torque tends to reverse. But it will not do so instantaneously, for that would mean a sudden increase in the total torque and hence in the twist of the bolt. Instead, the friction torque will pass gradually to a torque in the reversed sense in such a way as to hold the bolt twist at its maximum value in spite of the reduction of normal pressure torque consequent to the reduction of load. Finally the friction torque will be at the limiting value in the reversed sense (i.e., now in the same sense as the pressure torque, the loosening sense), and further reduction of load will reduce both normal pressure torque and friction torque. Thus during unloading the normal pressure torque and the friction torque combine. The reaction on the nut is also the combined torques acting in the loosening sense. At the point where the limiting frictional torque is developed, the total torque is still at the

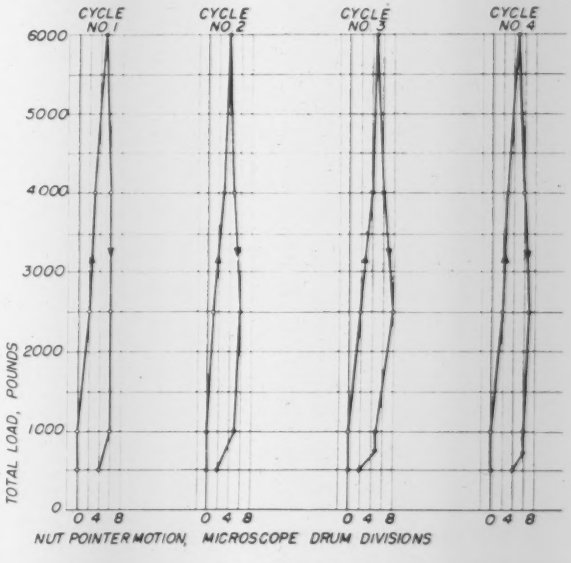

FIG. 3 CYCLES OF NUT-POINTER READINGS

maximum value, but the load and hence the base friction are small. These conditions appear favorable to slip of the nut. If it occurs it cannot be recovered because the total torque on the nut is at all times in the loosening sense. The whole process is aptly described as that of a "frictional ratchet."

The events of the cycle as thus predicted would produce curves such as those in Fig. 3. In cycle 2 for instance, the curve goes out to the right corresponding to bolt twisting during loading. As unloading begins, the twist tends to remain at the maximum value until the load is down to about 1000 lb. Then the curve bends to the left again, corresponding to the bolt twisting

back. But the curve does not return to zero twist. The residual positive (loosening) rotation corresponds to slip of the nut. Cycle 3, if plotted on the same horizontal axis, would proceed directly upward from the final point of cycle 2. For at this point again, the direction of rotation of the bolt in the nut tends to reverse on account of the increase of normal pressure torque accompanying increase of load. Again the friction torque will not reverse instantaneously but gradually, remaining for a while below the limiting value in such a way as to hold the bolt twist where it is. When the limiting value is reached the bolt starts to twist again.

FURTHER MEASUREMENTS TO TEST THE THEORY

The theory predicts twisting of the bolt as the tensile load is applied. This could occur only if the nut and bolt were acting as a reversible screw mechanism, that is, if the ordinary circumferential friction were only partly effective. Thus demonstration of the twist by torsion measurements directly on the bolt body would establish the basis of the theory—deviation of friction from the circumferential direction during loading and unloading.

Such measurements are shown in Fig. 4, having been taken simultaneously with the nut-pointer readings in Fig. 3. Pointers and microscopes were used on diametrically opposite sides of the bolt, Fig. 5, and the readings were averaged to eliminate error due to bending. It will be observed that the general form of the cycles is in conformity with the theoretical cycle, as also is the sense of the twist. It will also be observed that the readings, which represent rotation of a pointer brought up from a section of the bolt some 18 in. below to the microscopes in Fig. 1, are larger than the nut-pointer readings in Fig. 3. This is not to be expected from the theory as it has been given. For if the nut remains fixed, the rotation of the top of the bolt, where the microscopes are attached, is necessarily greater relative to it than relative to the section near the lower end of the bolt where the bolt pointers are attached. There is more twist of the bolt below this section, and even in the machine itself, before anything which can be called "fixture" is reached. If the nut slips, its rotation relative to the microscope would still further exceed that of the bolt pointers.

A "dummy nut and bolt," was made as a solid piece. If, therefore, the testing machines apply pure tension, no twist would be found. In fact, however, tests in all three machines showed twist in the same sense as, but to somewhat smaller amount than, the twists found in the genuine nut and bolt specimens. It appears therefore that the testing machines apply small twists as well as tensions. These may arise from screw

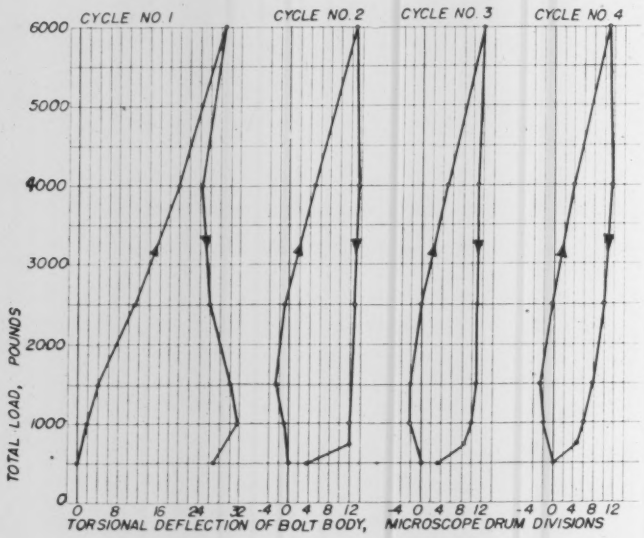

FIG. 4 CYCLES OF BOLT POINTER READINGS

threads through which the loads are transmitted, or even from inevitable imperfections such as slight curvatures of the testing-machine columns, which bend and produce twist at the heads as the machine is loaded. The bolt twists measured were extremely small, the corresponding torques being of the order 4 to 8 in-lb.

Measurements made on one machine (Amsler) of the rotation of the lower head, relative to the concrete floor, in which the machine is set, showed a rotation, of the sense which would screw the bolt into the nut, and of the same order as those in Fig. 4. Now the theoretical account of the events of the cycle rested on the assumption that the lower end of the bolt was fixed, and it failed to agree with the observations in one respect; the observed bolt-pointer readings are larger than the accompanying nut-pointer readings. This can now be explained as follows:

Suppose that the upper end of the bolt and the nut are held fixed, and the lower end of the bolt is twisted so that the tendency is to screw the bolt into the nut. The bolt pointers will show a "positive" rotation in the microscopes. The nut pointers will show no rotation. Let the tension now be applied, and suppose that the torque which automatically appears on the bolt threads within the nut is somewhat larger than the torque originally applied to the lower end of the bolt; then the bolt twist increases. The bolt within the nut turns in the loosening sense. The microscopes, carried by the bolt, show a positive increase of bolt pointer reading, and a nut pointer reading of the same amount. The total bolt pointer reading now exceeds the nut pointer reading.

Correspondence with this theoretical account would require that the twist of the genuine nut and bolt specimen be greater than that of the dummy specimen under the same load. The measurements, however, are too variable to be conclusive on this point.

EQUILIBRIUM OF A NUT UNDER FLUCTUATING LOAD

The possibility of nut loosening according to the present theory of frictional deviation can be analyzed by evaluating the external torque required to unscrew the nut. If this becomes negative, as it will in the extreme case of radial friction, the nut by itself, i.e., without external torque, cannot remain in equilibrium and will loosen by small amounts of slip in each cycle of load.

There is a well-known formula for the external torque required to unscrew, but it assumes purely circumferential friction and so is appropriate only to steady load. Also, it is now necessary to distinguish between the torque required during loading when the nut is expanding, and during unloading when it is contracting. The radial-friction components (down the slope of the V thread in a plane through the axis) are in opposite directions in the two cases, the normal pressure is different, and the circumferential friction is also different. There is a circumferential component even if the nut does not slip, because the bolt twists elastically and so turns within the nut.

During loading the radial-friction components on the bolt thread are outward. The twisting of the bolt, with or without slip of the nut, means a relative circumferential displacement in the unscrewing sense. The circumferential friction components will oppose this and will therefore provide a torque in the screwing-up sense on both bolt and nut. The formula for the external torque T, just sufficient to unscrew the nut is

$$T_1 = Lr \left\{ \frac{\mu(\sin\gamma\cos\alpha - \cos\gamma\sin\alpha\sin\beta) - \sin\alpha\cos\beta}{\mu(\sin\gamma\sin\alpha + \cos\gamma\cos\alpha\sin\beta) + \cos\alpha\cos\beta} + p\mu\sin\gamma \right\} \quad \ldots\ldots\ldots [1]$$

where L is the load, r the pitch radius, β the half-angle of the thread (30 deg for standard V thread), α the (small) helix

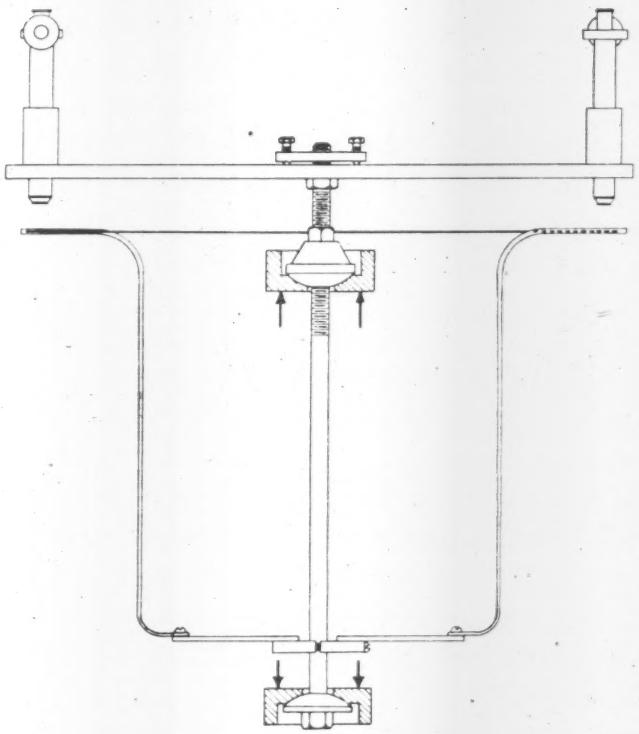

FIG. 5 BOLT AND NUT POINTERS

angle, and μ is the ordinary coefficient of friction (for the threads). The friction force is μN, where N is normal pressure. The circumferential component is denoted by $\mu N \sin \gamma$ and the radial (down the V slope) by $\mu N \cos \gamma$. The angle γ is a measure of the deviation of the friction forces from the radial direction. The ratio of the two is tan γ; and since the relative velocity (of registering points on the two threads) and the friction force are to have the same direction, this will be the ratio of v_c, the circumferential component of relative velocity, to v_r, the radial component (down the V slope). The term $p\mu \sin \gamma$ accounts for friction at the base, where the effective radius is larger than r. The value of p for the $^3/_4$ in-10 regular nut is about 1.37.

For a given thread and a given coefficient of friction, the ratio T_1/Lr can be plotted as a function of γ. The curve for the $^3/_4$ in-10 N.C. thread with $\mu = 0.15$ is shown in Fig. 6, with the designation "loading."

The external torque just sufficient to unscrew the nut during unloading may be evaluated for the last part of the unloading process in which limiting friction has been reached and untwisting of the bolt is under way. It has already been pointed out that the friction torque as well as the normal pressure torque is then in the unscrewing sense; the bolt while untwisting tends to carry the nut around with it in the unscrewing sense (for the nut). The radial friction is also reversed of course. The external torque to loosen is now

$$T_2 = Lr \left\{ \frac{\mu(\sin\gamma\cos\alpha - \cos\gamma\sin\alpha\sin\beta) + \sin\alpha\cos\beta}{\mu(\sin\gamma\sin\alpha + \cos\gamma\cos\alpha\sin\beta) - \cos\alpha\cos\beta} + p\mu\sin\gamma \right\} \quad \ldots\ldots\ldots [2]$$

The curve of T_2/Lr as a function of γ for the $^3/_4$-in. N.C. thread is shown in Fig. 6, with the designation "unloading." It will be observed that the torque is negative for all values of γ up to 90 deg, that is, an external torque is required to prevent the nut from unscrewing.

This does not mean, however, that the nut may have a large circumferential velocity (γ approaching 90 deg) in the end part of the unloading, for the conditions under consideration (the twisting back of the bolt) can exist only if the bolt twisted outward during the loading process. The curved marked "Bolt torque during loading" (which is given by Equation [1] without the base-friction term $p\mu \sin \gamma$) in Fig. 6 shows negative torque, i.e., unscrewing torque, only for γ less than about 16 deg. The circumferential displacement due to bolt twist during loading is therefore limited to about tan 16 deg, or about 0.3 times the elastic radial displacement. Any slip of the nut during the twisting back of the bolt in unloading will be less than this, otherwise the relative circumferential velocity would be reversed and the friction torque would be opposing instead of helping the slip.

The value of γ in the present tests can be estimated. Fig. 3 shows that the relative rotation of bolt and nut during the loading process is about 5 drum divisions or 10.65×10^{-6} rotations. The corresponding circumferential displacement is 2.26×10^{-5} in. The radial contraction of the nut during unloading is estimated at about 2×10^{-4} in. from previous measurements on $1^1/_4$-in. nuts by one of the authors.[3] This would mean a displacement of about 2.3×10^{-4} in. down the slope of the thread in the radial plane. The ratio of circumferential to radial velocity may be taken as the ratio of the displacements and is 0.113. This is tan γ, and γ is, consequently, about 6 deg. Since this is within the range of negative bolt torque for loading, slip of the nut is well accounted for by this theory. If the machine itself had not imposed a twist the circumferential displacement and hence tan γ would have been greater.

The theory is of course not quantitatively accurate. The radial expansion of a nut decreases rapidly from the base up, and

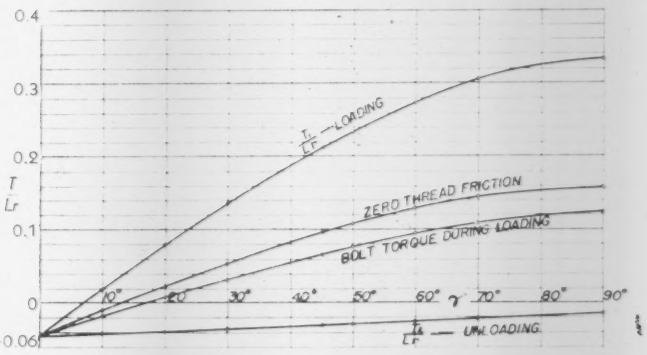

FIG. 6 THEORETICAL NUT AND BOLT TORQUE CURVES

this means a similar variation of γ. The curve in Fig. 6 marked "Zero Thread Friction" shows what the torque required to unscrew would be if the threads were frictionless, but the base retained the coefficient 0.15. It is positive, that is, the base friction is adequate to withstand the normal pressure torque, except for small values of γ. The difference between this and the "unloading" torque emphasizes the point that during unloading the friction torque on the threads helps to unscrew the nut.

DERIVATION OF FORMULAS FOR LOOSENING TORQUE

In Fig. 7(*a*), *O* is a point on the upper thread surface (the axis of the screw is vertical); *Ob* is normal to this surface; *Oc* is the tangent to the helix through *O*, and *Oa* is at right angles to *Ob* and *Oc*. It does not lie exactly in the section formed by a radial plane passing through *O* and the axis of the thread. The half-angle of the thread in such a section is denoted by β. The angle α is the angle of the thread helix.

In Fig. 7(*b*), *Od* is horizontal and in the radial plane; *Oe* is vertical; *Of* is at right angles to both, and so horizontal. Unit vectors along *Od*, *Oe*, *Of* are denoted by **i**, **j**, **k**, and unit vectors along *Oa*, *Ob*, *Oc* by **i**′, **j**′, **k**′.

By rotating the triad *Od*, *Of*, *Oe* about *Od* by the angle α, *Of* is

brought to Oc, and Oe to an intermediate position Og, Fig. 7(*b*). Then by rotating Od, Oc, Og about Oc by an angle β', Od is brought to Oa, and Og to Ob. The angle β' is nearly equal to β on account of the smallness of the helix angle α, and will now be replaced by β.

Resolving $\mathbf{j}'$ along Og, Od

$$\mathbf{j}' = \mathbf{j}'' \cos \beta + \mathbf{i} \sin \beta$$

Also

$$\mathbf{i}' = \mathbf{i} \cos \beta - \mathbf{j}'' \sin \beta, \quad \mathbf{k}' = \mathbf{k} \cos \alpha - \mathbf{j} \sin \alpha,$$
$$\mathbf{j}'' = \mathbf{j} \cos \alpha + \mathbf{k} \sin \alpha$$

whence

$$\mathbf{i}' = \mathbf{i} \cos \beta - \mathbf{j} \cos \alpha \sin \beta - \mathbf{k} \sin \alpha \sin \beta \quad [3]$$

$$\mathbf{j}' = \mathbf{i} \sin \beta + \mathbf{j} \cos \alpha \cos \beta + \mathbf{k} \sin \alpha \cos \beta \quad [4]$$

$$\mathbf{k}' = -\mathbf{j} \sin \alpha + \mathbf{k} \cos \alpha \quad [5]$$

Let the thread drawn in Fig. 7(*a*) be that of a nut, the V section being in the plane of the paper and the helix descending as

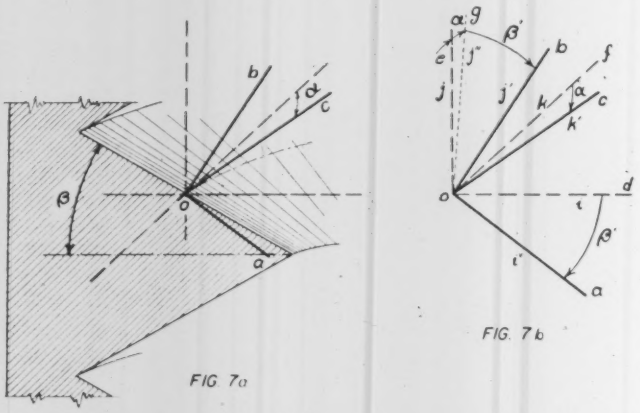

FIG. 7 NUT THREAD AXES

it goes back through the paper. The bolt is pulling down, and at the same time an external torque T_1 is applied to the nut in the unscrewing sense, of such magnitude that the nut is just about to turn.

The distributed forces on the thread surfaces can be concentrated for the present purpose. Fig. 8 shows the normal pres-

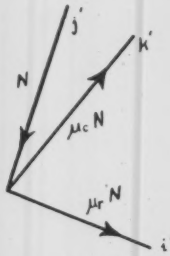

FIG. 8 THREAD FORCES

sure N with the friction μN resolved into components $\mu_c N$ along Oc and $\mu_r N$ along Oa, in the sense appropriate to the loading process when the nut is expanding radially. Then if γ is the angle in the plane $\mathbf{i}'\mathbf{k}'$ between the friction force μN and the direction of $\mathbf{i}'$

$$\mu_c = \mu \sin \gamma, \qquad \mu_r = \mu \cos \gamma \quad [6]$$

When the friction is entirely circumferential γ is 90 deg, and when it is radial γ is nearly, but not quite, zero. The difference (of the order of α) has already been disregarded in a previous paragraph.

The resultant force vector is

$$\mathbf{i}' \mu_r N + \mathbf{k}' \mu_c N - \mathbf{j}' N \quad [7]$$

and the vertical component is

$$\mathbf{j} \cdot (\mathbf{i}' \mu_r + \mathbf{k}' \mu_c - \mathbf{j}') N$$

Evaluating this by means of Equations [3], [4], and [5] and equating it to the load L on the nut

$$L = N (\mu_r \cos \alpha \sin \beta + \mu_c \sin \alpha + \cos \alpha \cos \beta) \quad [8]$$

which yields the value of N.

The $\mathbf{k}$-component of the force vector, [7], provides the torque of the thread forces about the axis. If r is the pitch-radius, this torque, tending to unscrew the nut, is

$$r\mathbf{k} \cdot (\mathbf{i}' \mu_r - \mathbf{j}' + \mathbf{k}' \mu_c) N$$

or

$$Nr (-\mu_r \sin \alpha \sin \beta + \mu_c \cos \alpha - \sin \alpha \cos \beta) \quad [9]$$

The friction torque on the base may be expressed as $pr\mu_c L$. Equilibrium of the nut then requires that

$$T_1 = Nr (-\mu_r \sin \alpha \sin \beta + \mu_c \cos \alpha - \sin \alpha \cos \beta) + pr\mu_c L \quad [10]$$

On substituting for N from Equation [8], and for μ_r μ_c from Equation [6], Equation [1] is obtained.

For unloading, the calculation is the same except that some changes of sign are required in Equations [8] and [10]. The nut is contracting radially instead of expanding, so the sign of all terms in μ_r must be changed. The circumferential friction is also reversed, because the bolt is now twisting back inside the nut. The sign of all terms in μ_c must therefore be changed. The base friction torque in Equation [10] remains unchanged. The result of these changes, the new torque required to loosen being called T_2, is the unloading Equation [2].

ACKNOWLEDGMENT

The authors are indebted to Mr. C. R. Otto for skillful execution of the tests.

EIGHTEEN years ago when chrome plating was first engaging the attention of engineers, William Blum, U. S. Bureau of Standards, in speaking of the extreme hardness of chromium and its remarkable resistance to corrosion, characterized these properties and their potentialities as "sensational." At that time high hopes were entertained that this hard silvery metal in thin coatings would solve once and for all the problem of wearing surfaces. Phrases such as "a panacea for wear" found expression.

As time went on and more and more experiments and applications revealed more clearly the true nature of plated chromium surfaces, it became evident that the virtues of this blue-white metal like the virtues of man were not without their failings. The technique of chrome plating, however, found general acceptance and its use has been credited with solving many machine-shop problems, reducing the cost of many operations as well as improving the quality of many products.

New applications of the technique are still being devised. Recently chrome plating has been applied to the faces of dies in such a manner as to overcome the inherent brittleness of chromium, which in the past has made its use on impact dies impracticable. By depositing a thin layer of the metal not in excess of 0.03 mm on highly polished surfaces of hardened carbon-steel dies designed for light- and medium-weight forgings, the life of the dies has been extended from 15,000 to 35,000 forgings. On forgings of thinner sections life of the dies has been extended from 2000 to 10,000 forgings. This application, however, is limited to carbon-steel dies because no particular success has been experienced with chrome plating on alloy steel dies.—*The Engineer's Digest*, vol. 6, no. 9, p. 247.

The GAS TURBINE *in* AVIATION

Its Past and Future

By S. R. PUFFER and J. S. ALFORD

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DURING the past year the gas turbine has been receiving more than its share of comment in the technical and semitechnical press. The impression might be gained that this type of power plant is something entirely new, were it not for the fact that most authors on the subject are careful to point to the accomplishments of Hero of Alexandria and John Barber of England, thereby demonstrating that "there is nothing new under the sun." Something new must have occurred, however, to make possible the fact that the gas turbine is now not only established, but established in that most critical branch of engineering—aviation. The vital something is, in a word, better materials. In the development of alloys for operation at high temperatures, the metallurgists have made and are continuing to make outstanding contributions. As a result of their accomplishments, the gas turbine has made rapid strides in the last few years, and it can safely be predicted that the gas turbine will continue to play an increasingly important part in the powering of aircraft.

SUCCESSFULLY APPLIED TO TURBOSUPERCHARGER IN 1918

The first successful application in this country of a gas turbine to an aircraft power plant occurred in September, 1918, when Dr. Sanford A. Moss, with a group of Army Air Corps representatives from McCook Field, took the first turbosupercharger, installed on a Liberty motor, to the top of Pikes Peak for test under altitude conditions. On this occasion it was demonstrated that the output of the Liberty engine, which was calibrated at 350 hp at sea level, was not only maintained but actually increased to 380 hp at an altitude of 14,100 ft, as shown in Fig. 1.

From that time until the present, the use of a gas turbine as the driving element of the turbosupercharger has progressed to the point where some question might legitimately arise as to which element supplies the more power, the turbine or the engine.

As an illustration of this increase in output of the gas turbine, relative to that of the engine, the curves in Fig. 2 are, it is believed, self-explanatory. From this it will be seen that at 35,000 ft, the power developed by the turbine is actually equal to the output of the engine without the turbine. At higher altitudes it is even greater.

In addition to its primary function of maintaining engine output at sea level, numerous other interesting functions for the turbosupercharger have been developed.

Its use for ground-boosting engines to increase power for take-off has long since become an everyday occurrence, as has its use under combat conditions to obtain emergency power far beyond the normal output of the engine. Perhaps the most important secondary function which has been developed is its contribution to extending the operating range of aircraft.

Contributed by the Oil and Gas Power Division and presented at the Semi-Annual Meeting, Chicago, Ill., June 18, 1945; also at a meeting of the Los Angeles Section, Los Angeles, Calif., June 14, 1945; and presented at the Annual Meeting, New York, N. Y., Nov. 26–29, 1945, of The American Society of Mechanical Engineers.

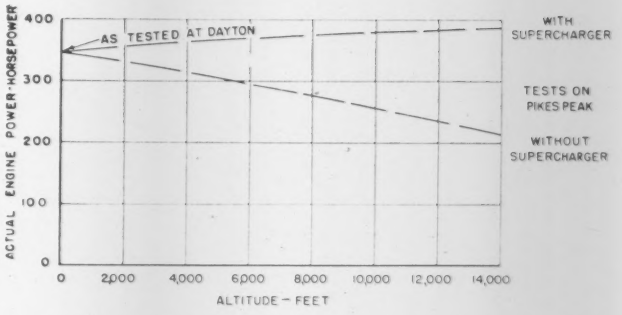


FIG. 1 POWER RECOVERY BY FIRST TURBOSUPERCHARGER INSTALLED IN LIBERTY 12-CYLINDER ENGINE (Tested on Pikes Peak, August–October, 1918.)

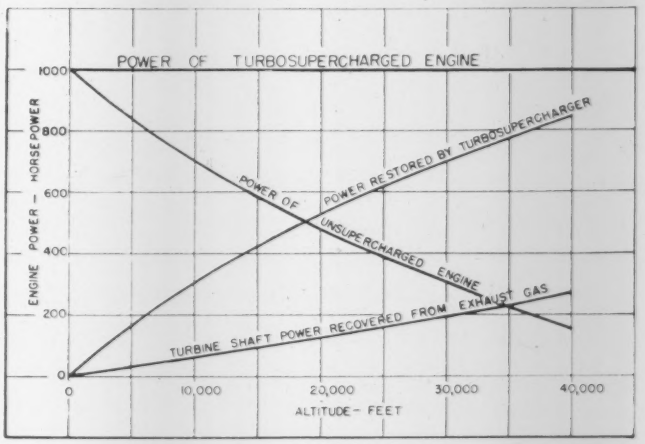


FIG. 2 POWER OF TURBOSUPERCHARGED ENGINE

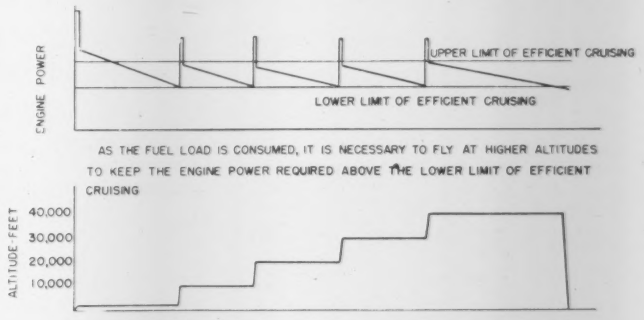


FIG. 3 FLIGHT PLAN FOR A LONG-RANGE MISSION

It has long been realized that the fuel economy of an aircraft engine is greatly improved when operating at from 30 to 50 per cent of its normal rated power at low engine speed, but with the highest intake-manifold pressure it is possible to hold. The turbosupercharger, on account of its favorable characteristics and ease of control, is more adaptable to this mode of opera-

tion than the superchargers driven by gears from the crankshaft. In fact, it involves nothing more complicated than closing the waste gate in the exhaust line and directing a greater proportion of the exhaust gases through the wheel. The translation of this principle into miles added to the range of a plane involves a detailed study of a number of items not a part of this paper; but as this study is of considerable interest and its effect of great importance to long-range aircraft, the procedure is outlined briefly in Fig. 3.

The plane takes off and flies at low constant altitude at its most economic cruising speed. At the start, when the plane is heavy with fuel, this brings it at the upper limit of the efficient cruising power range of the engine. As the flight continues, fuel is consumed; the plane becomes lighter and tends to speed up. In order to maintain the best cruising speed, it then becomes necessary to reduce power. This continues until the lower limit of efficient cruising is reached. When this point is reached, a climb is made to a higher altitude, such that the engine is again required to operate at the upper limit of its efficient cruising range, and the cycle repeated. This continues until the plane, in order to remain within the economic cruising limits of the engine, flies at stratosphere levels.

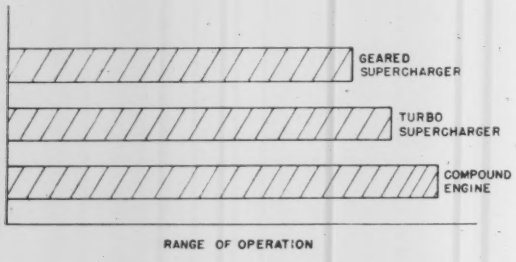


FIG. 4 LONG-RANGE TRANSPORT
(Comparative ranges for the same airplane and pay load.)

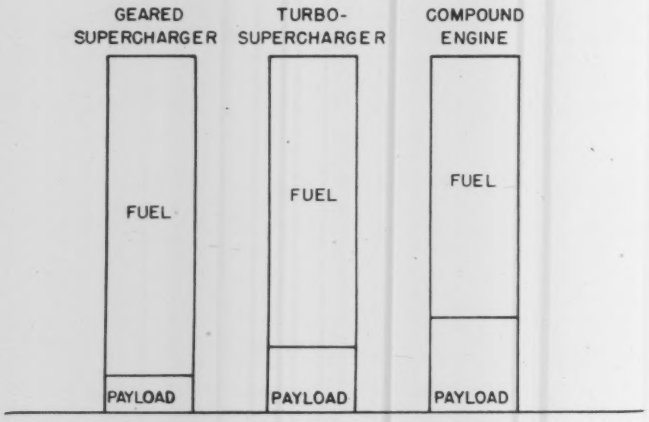


FIG. 5 LONG-RANGE TRANSPORT
(Comparative pay load and fuel loads for a given range.)

The benefits of the turbosupercharger under this flight plan are well illustrated in Figs. 4 and 5. It should be noted that still further improvement is possible with the compound engine, about which more will be said later.

One question which has been discussed at great length is that concerning the relative total output of an engine having a high degree of internal supercharging and making use of exhaust jets, compared with an engine with a turbosupercharger. It has proved to be an interesting discussion, and a great deal of study has been put on the subject. One set of results from such studies is shown in Fig. 6. This indicates that for the lower altitudes the engine without a turbosupercharger and using exhaust jets seems to enjoy an advantage. At the higher altitudes the situation is reversed, and the turbosupercharger comes into its own. When the exhaust valve opens, the pressure in the cylinder of a highly boosted engine is still in excess of 100 psi which, when exhausted directly to atmosphere, will give an effective jet velocity of about 3000 fps, very much higher than can be used effectively. The velocity of a jet for efficient utilization should not be greatly in excess of twice the plane speed.

With a turbosupercharger, the energy in the exhaust is used first through the turbine wheel. Then, instead of letting the gas exhaust directly to atmosphere, it is exhausted into a region of low pressure in the order of 10 in. of mercury above ambient. The rest of the expansion is taken through a jet of the proper proportions to deliver an effective propulsion velocity.

These applications of a gas turbine which have been briefly outlined cover the advance of the art during the last 25 years. Although the period may seem long, progress at the beginning was slow and difficult, often almost to the point of complete discouragement. At these times the sympathetic understanding and support of the Army Air Forces, and their determined faith in the ultimate success of the development, were of the utmost help in keeping this development alive.

Many interesting articles could be written concerning the improvements which have been made in high-temperature alloys, development and lubrication of high-speed bearings, resonant vibrations at "ultraviolet" frequencies, elimination of distortion due to high differential temperatures, improvements in compressor and turbine designs, and other kindred topics, but time prevents more than their mere mention in this paper.

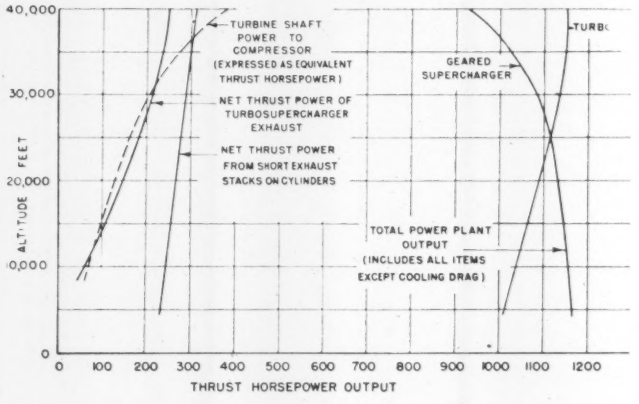


FIG. 6 COMPARISON OF THRUST HORSEPOWER OF TURBOSUPERCHARGED VERSUS GEAR-DRIVEN COMPRESSOR ON RECIPROCATING ENGINE, BASED ON AIRPLANE SPEED OF 500 MPH

FUTURE TREND OF GAS-TURBINE DEVELOPMENTS

The successful accomplishment of these earlier phases of gas-turbine work has provided a firm base from which to "take off" on the greater and more important developments now under way and confronting us in the near future. The future prospects for the gas turbine in aviation are, indeed, bright.

It is fully expected that turbosupercharging as it has been developed will continue in general use, at least for military applications. The ultimate of high-altitude operation has not yet been attained, and the more general use of cabin supercharging will encourage flying at still higher altitudes than are now practical. Some commercial application may result on the basis of its favorable effect on cruising performance.

Beyond this usage lie three major developments, each of which it is believed will have a decided effect on future aircraft design. These are as follows:

1 The compounding of an internal-combustion engine with a gas turbine.

2 The use of a gas turbine for straight jet propulsion.

3 The use of a gas turbine for combined propeller and jet propulsion.

The compounding of an exhaust-gas turbine with an internal-combustion engine or, to use the more modern phraseology, the use of an internal-combustion engine as a topping unit for a gas turbine has long presented intriguing possibilities. Some designers have wanted to use the power for driving accessories, others for the removal of boundary-layer air, others for still different schemes. The simplest and most direct is to return the extra available power to the crankshaft.

Three obstacles as follows have prevented earlier use of this principle:

1 Effective compounding requires the use of engine back pressures higher than have been thought practical by the engine manufacturers. The improvement in output with increasing pressure is clearly indicated in Fig. 7. Adequate exhaust pressures are being rapidly approached in service where turbosuperchargers have been used, so that the fear of immediate disaster to the engine is disappearing.

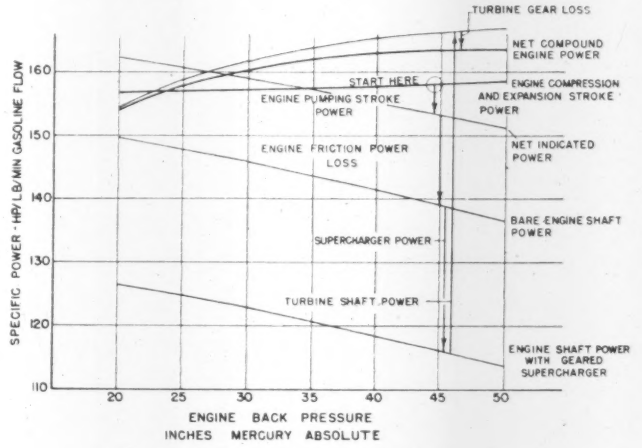


FIG. 7 COMPOUND ENGINES

(Breakdown of engine and turbine powers at 30,000 ft.)

2 Close-coupling of the supercharger to the engine results in hotter operating temperatures; and materials which would withstand this service have only recently become available.

3 Some added weight and complications result. Exhaust manifolds must be made stronger and tight against gas leakage. Suitable gearing must be arranged between the turbine and crankshaft, which may or may not involve overrunning clutches, or speed-changing devices to disengage the turbine wheel when it is not required or when it is not operating to best advantage.

The resulting power plant will involve all of the complications of each unit, as well as some not found in either. The improved performance from this combination, considering both the increase in power output, and hence the reduction in specific weight and also the expected improvements in fuel economy, is so great as to make the compound engine a power plant of great promise for many purposes.

The remaining and most attractive uses for the gas turbine are in the field of direct propulsion rather than as accessory units. It is in this field that the greatest advance is expected, and it is this phase of the development that is expected to exert the greatest influence on future aircraft design.

APPLICATION TO JET AND PROPELLER DRIVES

The first of these, jet propulsion, is already an accomplished fact and has been widely publicized.

Although the gas turbine as applied to jet propulsion is already here, the application of this type of power plant to propeller drive has long been considered. The freedom from vibration, simplicity of control and installation, and the ability to burn fuels other than gasoline have made it an attractive study.

In any gas turbine the net shaft power available is the differential between the power required to compress the air and that delivered by the turbine. In most gas-turbine cycles between 65 and 75 per cent of the total turbine output is required to drive the compressor, leaving only from 25 to 35 per cent of the output as net power. For this reason, any change in the power required for compression of the air or delivered by the turbine, both of which are relatively large values, will have a greatly multiplied effect on the net output, which is a relatively small value. For this reason, strict attention to all details

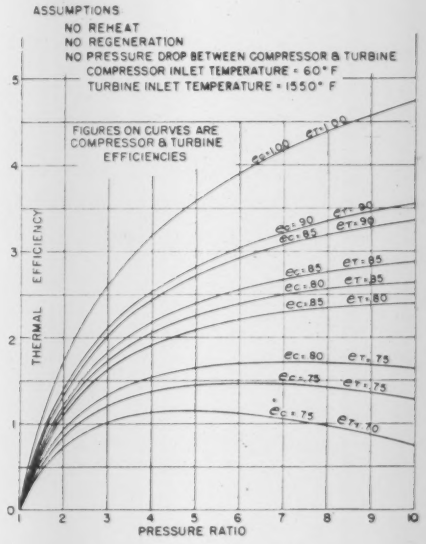


FIG. 8 OPEN CYCLE GAS-TURBINE EFFICIENCIES

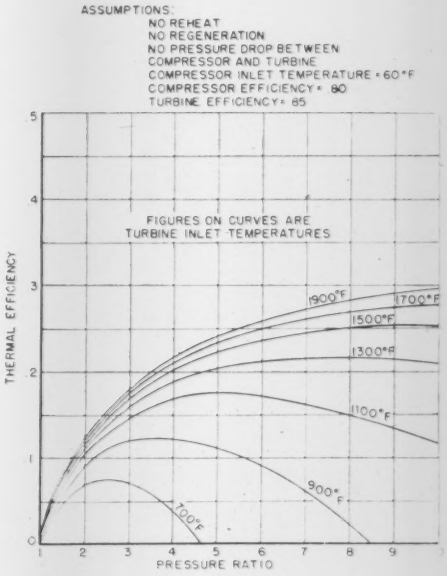


FIG. 9 OPEN CYCLE GAS-TURBINE EFFICIENCIES

necessary to improved efficiency will result in profitable dividends. Just how these gains in net output increase for relatively small improvements in compressor and turbine efficiencies can be seen in Fig. 8, based on a constant gas temperature of 1550 F, which is entirely reasonable.

Another feature, greatly affecting performance and economy, is the temperature of the gases entering the turbine. In most commercial and industrial applications of the gas turbine where long life is essential, the temperatures quoted are from 1000 to 1200 F. In aircraft applications where lightweight is of paramount importance, gas temperatures as high as 1750 F are now possible; and if the present rate of improvement in

materials continues, temperatures of 2000 F are not far distant. The effect of these higher operating temperatures on improved performance can be seen in Fig. 9.

To absorb all of the power in the turbine wheel would involve a bucket design with small exit angles, which in turn would mean a relatively tall bucket. This in turn would increase the operating stresses, which would either limit operating speeds, shorten life, or both. Consequently, it has been found expedient to use a shorter bucket which has lower stresses. This means a greater bucket exit angle and higher leaving losses from the turbine wheel. This does not mean a loss in over-all performance, as the energy remaining in the gases after they pass through the wheel can be utilized in a jet.

This indicates that most propeller-type turbines, particularly those designed for use in high-speed planes where a jet can be used effectively, will get their power both from the propeller drive and the jet, a ratio looked on with favor being about 75 per cent and 25 per cent, respectively, although the amount delivered by the jet can be adapted to suit the requirements of the plane on which the power plant is installed.

At the present state of development, it is not possible to predict for the gas turbines the low cruising fuel consumption now possible with some of the modern, highly refined reciprocating engines. This is partly due to the fact that as yet only the simplest gas-turbine cycles have been studied. Improvements can, of course, be made by the use of intercoolers at the compressor end, and regenerators and reheaters at the turbine end, but these improvements add weight and complication. It is believed preferable to carry the simplest possible cycle as far as possible before starting to introduce the complications.

ADVANTAGES OF GAS TURBINE AS MAIN POWER PLANT

In its present simple form the gas turbine, either propeller drive or jet, has numerous attractive features, which have been frequently mentioned but which may be reviewed briefly as follows:

1 Freedom from vibration, permitting lighter propeller sections and mounting structure.

2 Simplicity of control; only one lever required for controlling the speed and power of the unit.

3 No radiators or other cooling surface to add weight and drag on jet units. Very small coolers for gear lubricant on the propeller type.

4 Negligible cooling air required. Conventional engines require from 5 to 8 times as much air for cooling as is required by the engine itself. The acceleration of this air up to plane speed represents an appreciable loss of power, particularly in climb, even though much of this may be later recovered by the use of carefully designed radiators and the utilization of the Meredith effect.

5 No spark plugs required for operation. After combustion is once established, it is self-supporting.

6 No carburetors, hence no icing, no mixture controls.

7 Available supply of compressed air, not contaminated by oil or gasoline, for supercharging the cabin.

8 Quietness of operation. Less fatigue for the pilot, or less cabin insulation to deaden noise.

9 Decreased fire hazard due to ability to use fuels other than gasoline.

10 Lower specific weight.

11 Less consumption of lubricating oil.

This brief review covers the past history of the gas turbine as applied to aircraft, as well as plans for its future expansion and application. It will be seen that, from its original start as a power-plant accessory, of modest output and for long regarded by many as of doubtful value, it has rapidly increased in output and relative importance until the present time when it is taking its place alongside of the latest and most highly developed reciprocating engines as a recognized means of aircraft propulsion.

COMPARISON OF TYPES OF POWER PLANTS

As a means of better showing where the different types of power plants stand with respect to each other, two comparisons are here outlined. The first of these, shown in chart form in Tables 1 and 2, presents comparisons by weight and fuel economy, respectively, of various types of power-plant installation.

As a second means of comparing different types of power plants, each type has been assumed installed on a pursuit airplane. The weight of power plant, fuel, and fuel tanks has been kept constant in this comparison. In order to fix the

TABLE 1 SPECIFIC POWER-PLANT WEIGHT
(Pounds per military brake-horsepower*)

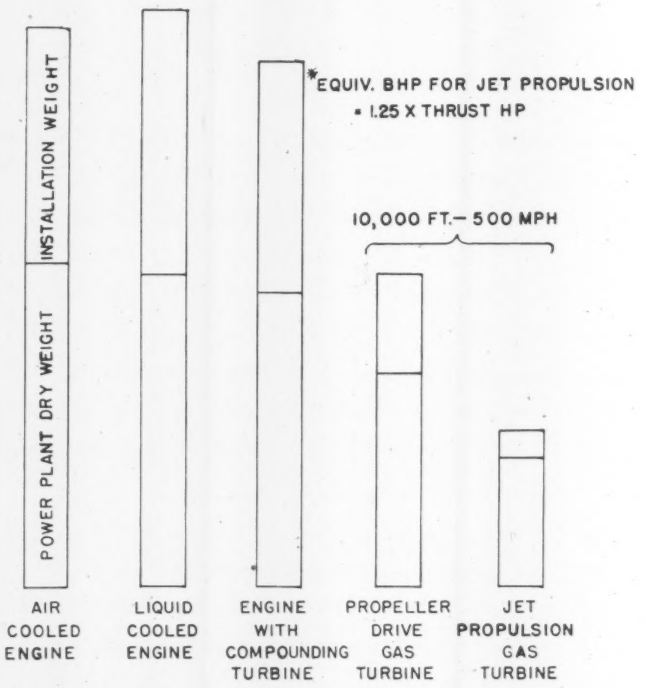
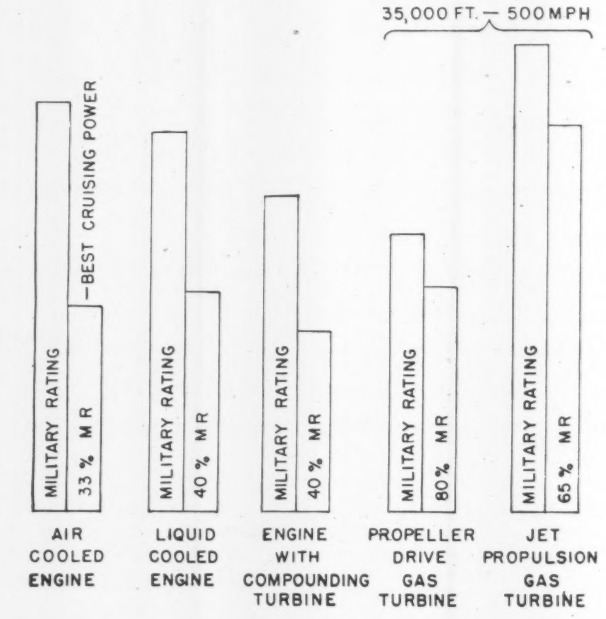


TABLE 2 SPECIFIC FUEL CONSUMPTION AT MILITARY RATING AND AT RATING GIVING BEST FUEL ECONOMY



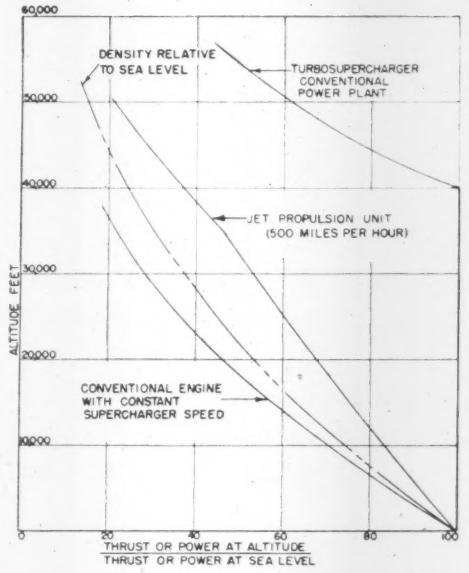


FIG. 10 VARIATION OF THRUST OR POWER WITH ALTITUDE

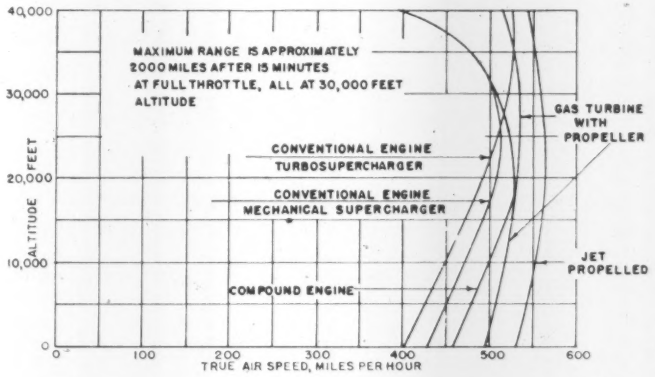


FIG. 11 MAXIMUM SPEED VERSUS ALTITUDE

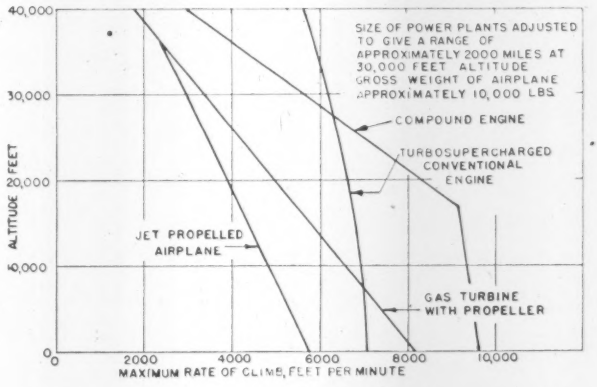


FIG. 12 VARIATION OF MAXIMUM RATE OF CLIMB WITH ALTITUDE

weight of fuel and fuel tanks, the radius of action has been assumed as approximately 1000 miles at 30,000 ft altitude.

The results of these calculations cannot be taken as absolute values, but it is believed that they do give a reasonable idea of the relative performance which may be expected. It is further pointed out that the new gas-turbine units offer possibilities of improvements in the plane itself which would react in their favor.

Since gas turbines are not supercharged, the power or thrust output decreases with decreasing air density. However, the cold air found at high altitudes has a favorable effect upon the over-all gas-turbine output. This partially makes up for lack of supercharging, as shown in Fig. 10. This factor will explain why, in the following curves, the performance of the airplane powered by gas turbine does not decrease as much as might be expected at high altitudes.

Comparisons are shown in Figs. 11, 12, 13, and 14. In addition, Fig. 15 shows the fuel consumption as a percentage of take-off weight for different ranges.

From these curves, the following conclusions may be drawn:

1 For the utmost in speed, disregarding other considerations, jet propulsion is by far the best performer.

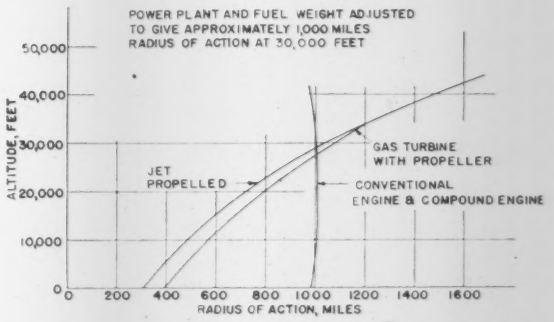


FIG. 13 RANGE FOR DIFFERENT ALTITUDES

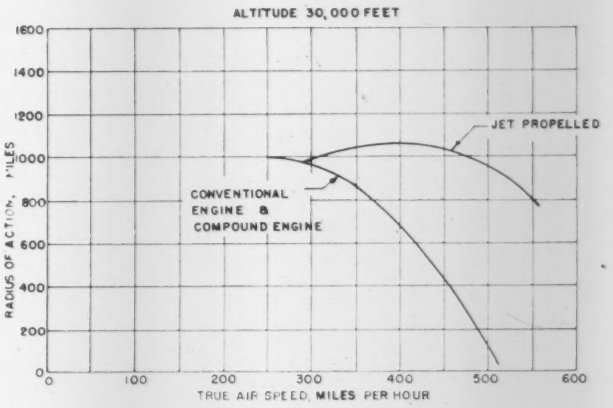


FIG. 14 VARIATION OF RANGE WITH AIR SPEED

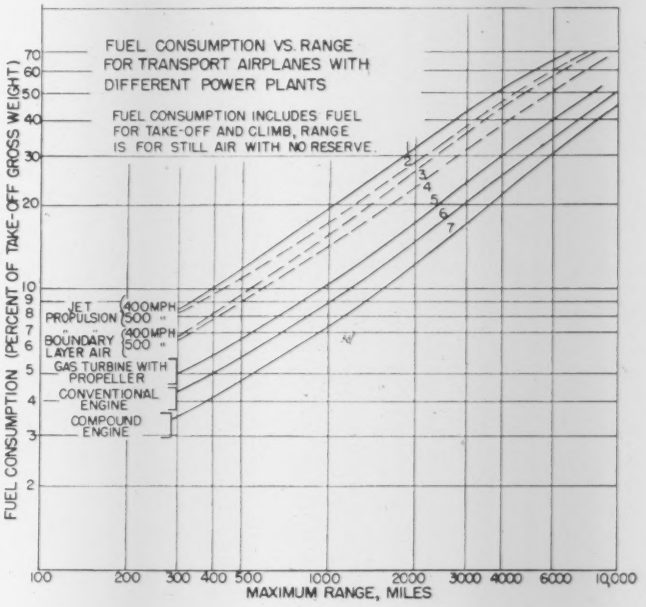


FIG. 15 FUEL CONSUMPTION VERSUS RANGE FOR TRANSPORT AIRPLANES WITH DIFFERENT POWER PLANTS

(Fuel consumption includes fuel for take-off and climb, range is for still air with no reserve.)

2 For operation at extreme ranges, the internal-combustion engine, compounded with an exhaust-gas turbine gives by far the best performance. This compound engine combined with water injection provides a power plant with a tremendous reserve of power at sea level and at all altitudes up to the critical, or the point where the turbine nozzle pressure starts to fall off. This is reflected in a very high rate of climb, surpassing that of any other power plant.

3 The gas turbine-propeller combination provides a power plant which, on account of its low specific weight, gives a performance approaching that of the jet unit at all but extreme altitudes, but with much better range.

4 For operation at extreme altitudes, the present internal-combustion engine, equipped with a modern turbosupercharger and properly utilizing the exhaust gas through a jet,

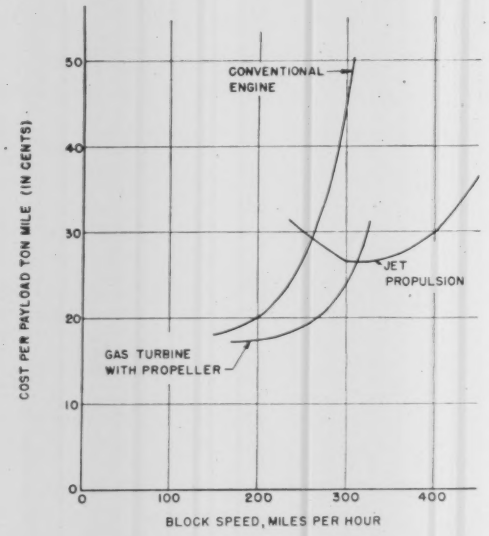


FIG. 16 COST PER PAY LOAD TON-MILE FOR TRANSPORT AIRPLANE OF 60,000 LB GROSS WEIGHT
(Length of trip = 500 miles.)

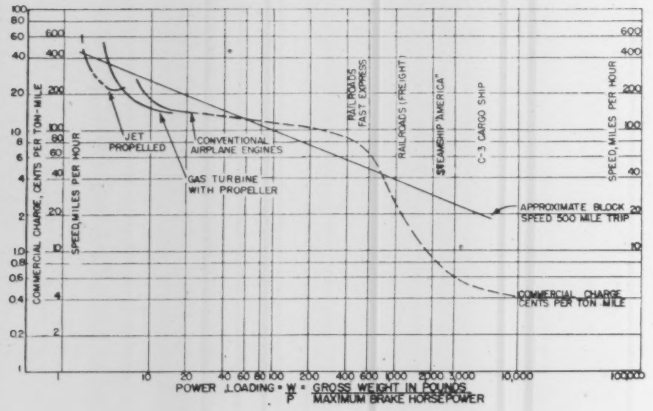


FIG. 17 COST PER TON-MILE OF TRANSPORTING CARGO
(Pay load composed entirely of cargo.)

is nearly equal to the jet-propulsion unit in speed and far surpasses it in climb.

CONCLUSION

In closing, it might be of interest to attempt a look into the future. This is admittedly a highly controversial venture; but as a means of stirring up interest and creating discussion, it may prove worth while.

The remark is frequently made that jet propulsion is purely a military device and that, on account of its relatively high fuel consumption, it can have no commercial application. Edward P. Warner, in an excellent and comprehensive paper,[1] has broken down the economics of commercial transport operation into its many component parts. An attempt has been made to reassemble this breakdown around a jet-propelled transport plane. Several assumptions are necessary in so doing; but, assuming the inherent greater reliability of a turbine unit, the higher rate of speed and, consequently, greater number of trips, coupled with the fact that the fuel required is not high-octane gasoline but any one of a number of much less costly fuels, we come up with an answer which indicates that jet propulsion may find a place in postwar transport along with the present conventional power plants. For flights not greatly in excess of 500 miles, the cost of jet-propulsion transport is only slightly higher than the cost of present-day transport, but the cruising speeds are much higher, as shown in Fig. 16.

The curve, Fig. 17, shows the cost of transport in cents per ton-mile, and speed of travel against power loading and embodies most of the methods of transportation now in use throughout the world. Here again it will be observed that the cost of jet-propelled air transport falls closely on the general curve.

For distances greater than 500 miles in a single flight, the cost becomes rapidly higher and could only be justified on the basis of extreme urgency.

The propeller-drive gas turbine will, it is expected, have an even wider application to air transport, as its many excellent qualities make it particularly suited for this type of application. Further elaboration on this subject will undoubtedly be made by those who have this study under consideration.

In making the various analyses discussed, there were available no formulas for the performance of planes with unconventional power plants. It therefore became necessary to develop these as the work progressed. An Appendix is included which gives some of these formulas, and it is hoped that those interested will review them in the light of their own experience. Only by discussion and comparisons can the validity of these formulas be established, pending the results of extended flight testing.

ACKNOWLEDGMENT

The authors gratefully acknowledge the valuable assistance given by Messrs. L. J. Fischer, E. L. Auyer, W. V. Hurley, and others in their preparation of different parts of this presentation.

Appendix

PRELIMINARY PERFORMANCE CALCULATIONS OF AIRPLANES POWERED WITH JET-PROPULSION UNITS

Analytical relations between basic aerodynamic characteristics, the power-plant characteristics, and the resulting performance data of an airplane are helpful in making preliminary performance calculations. Of particular interest are approximate formulas for maximum range, which usually results from flying at progressively higher altitudes as the fuel is consumed.

BASIC AERODYNAMIC EQUATIONS

The basis of the relations which follow is the assumption of a parabolic relation between the lift and drag coefficients for the airplane. In the speed range where compressibility shock causes an additional increase in the drag, the parasitic drag should be increased by the required amount.

The basic relation between the lift and drag coefficients is taken as

$$C_D = C_{DP_e} + \frac{C_L^2}{\pi A R_e} \quad \ldots\ldots\ldots\ldots\ldots [1]$$

where

[1] "Post-War Transport Aircraft," by E. P. Warner, published in the *Aeronautical Engineering Review*, vol. 2, 1943, p. 7.

C_D = drag coefficient = $\dfrac{391D}{\sigma V^2 S}$

C_L = lift coefficient = $\dfrac{391L}{\sigma V^2 S}$

C_{DP_e} = effective parasite-drag coefficient

$AR_e = \dfrac{eb^2}{S}$ = effective aspect ratio

e = airplane efficiency factor (Oswald)

b = wing span, ft

S = wing area, sq ft

V = true air speed, mph

$\sigma = \dfrac{\rho}{\rho_0} = \dfrac{\text{Air density at altitude } Z}{\text{Air density at standard sea-level conditions}}$

ρ_0 = 0.002378 slugs per cu ft

L = lift of wings, lb

D = aerodynamic drag of airplane in level flight, lb

The power required by the airplane in level flight follows from Equation [1] to be

$$\frac{P_r}{W} = \frac{6.85}{l_p}\sigma\left(\frac{V}{100}\right)^3 + \frac{0.332\,l_s}{\sigma V} \quad \ldots\ldots [2]$$

where

P_r = thrust horsepower required in level flight

W = gross weight of airplane, lb

$l_p = \dfrac{W}{f}$ = parasite loading, psf

$f = C_{DP_e}S$ = equivalent parasite area, sq ft

$l_s = \dfrac{W}{eb^2}$ = effective span loading, psf

$eb^2 = AR_eS$ = (effective span),^{2} sq ft

The net thrust required for level flight is related to the thrust power required by the relation

$$D = \frac{375P_r}{V} \quad \ldots\ldots [3]$$

Combining Equations [2] and [3] yields an equation for the ratio of the aerodynamic drag to the gross weight

$$\frac{D}{W} = \frac{0.00255}{l_p}\sigma V^2 + \frac{124.5\,l_s}{\sigma V^2} \quad \ldots\ldots [4]$$

By equating to zero the derivative of the right-hand side of Equation [4], with respect to the velocity, the velocity of minimum drag is found to be

$$V_{ld} = 14.85\,\frac{[l_p l_s]^{1/4}}{\sigma^{1/2}} \quad \ldots\ldots [5]$$

Upon substituting Equation [5] into Equation [4], the minimum drag for level flight is found to be

$$D_{ld} = 1.128\,W\left[\frac{l_s}{l_p}\right]^{1/2} \quad \ldots\ldots [6]$$

$$= 1.128\,W\frac{f^{1/2}}{be} \quad \ldots\ldots [6a]$$

Several interesting relationships can be derived in terms of the two following ratios

$$\text{Thrust ratio} = \frac{\text{Net thrust available}}{\text{Minimum thrust required}} = \frac{F_n}{D_{ld}} \quad \ldots [7]$$

where

F_n = Net thrust from power plant, lb

$$\text{Velocity ratio} = \frac{\text{Velocity of airplane}}{\text{Velocity for minimum drag}} = \frac{V}{V_{ld}} \quad \ldots [8]$$

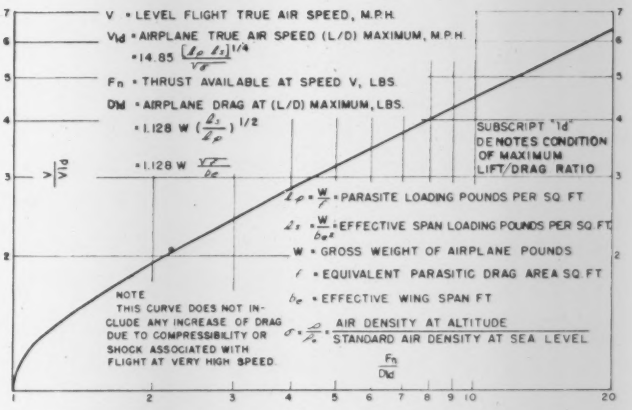


FIG. 18 VELOCITY RATIO VERSUS THRUST RATIO FOR LEVEL FLIGHT

The thrust-required equation can be put in the form

$$\frac{F_n}{D_{ld}} = \frac{1}{2}\left[\left(\frac{V}{V_{ld}}\right)^2 + \left(\frac{V_{ld}}{V}\right)^2\right] \quad \ldots\ldots [9]$$

A plot of this function is shown in Fig. 18. The velocity for, and the actual value of, minimum drag are first calculated for a given altitude from Equations [5] and [6]. A provisional value of the thrust available at that altitude is used for the initial determination of the thrust ratio from which the velocity ratio is determined from Fig. 18. Usefulness of this plot is due to the circumstance that, for the velocities of usual interest, the thrust available does not change very rapidly with respect to the velocity.

MAXIMUM LEVEL-FLIGHT VELOCITY

From Equation [8], the maximum level-flight velocity will be

$$V_{max} = \left(\frac{V}{V_{ld}}\right)V_{ld} \quad \ldots\ldots [10]$$

where

$\dfrac{V}{V_{ld}}$ corresponds to the maximum thrust available

V_{max} = maximum airplane speed, neglecting compressibility, mph

If the airplane velocity is sufficiently high relative to the velocity of sound to cause appreciable additional drag, the velocity, as determined by Equation [10], must be corrected by a compressibility factor. This factor varies among different airplanes. The correction does not usually become appreciable until the ratio of airplane velocity to the local velocity of sound is about 0.6 or greater.

MAXIMUM RATE OF CLIMB

The rate of climb is given by the equation

$$V_Z = \frac{33{,}000}{W}(P_a - P_r) \quad \ldots\ldots [11]$$

where

V_Z = rate of climb, fpm

P_a = thrust horsepower available

Substituting Equation [2] into Equation [11] yields

$$V_Z = 33{,}000\left[\frac{F_nV}{375W} - \frac{6.85}{l_p}\sigma\left(\frac{V}{100}\right)^3 - \frac{0.332l_s}{\sigma V}\right] \quad \ldots [12]$$

By equating to zero the derivative of the right-hand side of Equation [12], and making use of Equations [7] and [8], results in

$$\frac{F_n}{D_{ld}} = \frac{1}{2}\left[3\left(\frac{V_C}{V_{ld}}\right)^2 - \left(\frac{V_{ld}}{V_C}\right)^2\right] \quad \ldots\ldots\ldots [13]$$

Substitution of Equation [13] into [12] yields a somewhat simplified expression for the maximum rate of climb, in feet per minute

$$V_Z = \frac{V_C f_2}{(L/D)_{max}} \quad \ldots\ldots\ldots [14]$$

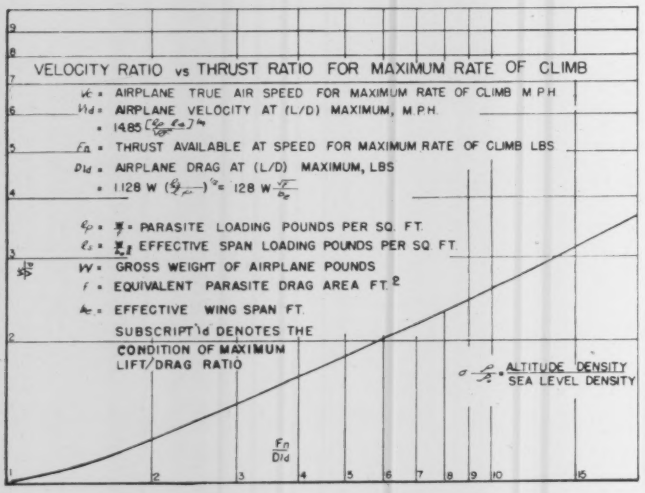


FIG. 19 VELOCITY RATIO VERSUS THRUST RATIO FOR MAXIMUM RATE OF CLIMB

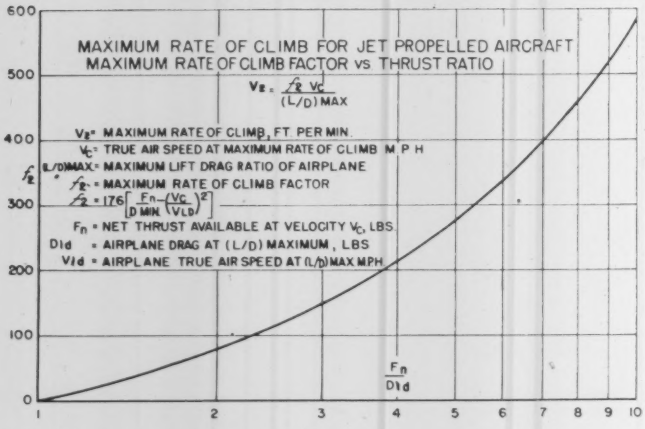


FIG. 20 MAXIMUM RATE OF CLIMB FOR JET-PROPELLED AIRCRAFT (Maximum rate of climb factor versus thrust ratio.)

where

$$f_2 = 176\left[\frac{F_n}{D_{ld}} - \left(\frac{V_C}{V_{ld}}\right)^2\right]$$

$(L/D)_{max}$ = maximum value of lift-drag ratio for airplane. Figs. 19 and 20 show curves for the thrust and velocity ratios.

If a new function ϕ, denoted as "thrust factor," is introduced, where

$$\phi = \frac{F_n}{\sigma F_0} = \frac{\text{Actual thrust available at altitude, lb}}{\sigma \times \text{Gross thrust at sea level and zero speed, lb}} \quad [15]$$

the absolute ceiling will correspond, so that the value of the density ratio

$$\sigma_a = \frac{\frac{W}{\phi F_0}}{(L/D)_{max}} = \frac{D_{ld}}{\phi F_0} \quad \ldots\ldots\ldots [16]$$

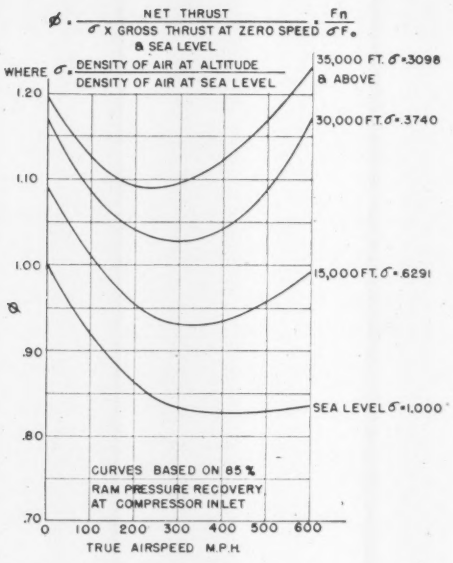


FIG. 21 VARIATION OF THRUST WITH AIR SPEED AND ALTITUDE

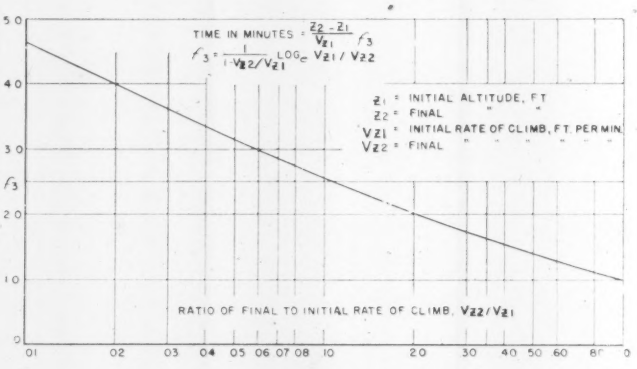


FIG. 22 TIME TO CLIMB

Values of the thrust factor ϕ are shown in Fig. 21.

Calculations of a number of actual cases have shown that an approximate linear relation exists between maximum rate of climb and altitude. Assuming a linear relation between fuel flow and altitude, and airplane speed and altitude during climb, the following useful relations result from integrating between altitude Z_1 and Z_2.

TIME TO CLIMB

A linear relation between the rate of climb and the altitude Z may be written as

$$V_Z - V_{Z1} = \frac{V_{Z2} - V_{Z1}}{Z_2 - Z_1}(Z - Z_1) \quad \ldots\ldots\ldots [17]$$

Integrating this expression for the time required to climb from Z_1 to Z_2 yields

$$t_C = \frac{Z_2 - Z_1}{V_{Z1} - V_{Z2}} \log_e \frac{V_{Z1}}{V_{Z2}} = \frac{Z_2 - Z_1}{V_{Z1}} f_3 \quad \ldots\ldots\ldots [18]$$

where

$$f_3 = \frac{V_{Z1}/V_{Z2}}{V_{Z1}/V_{Z2} - 1} \log_e \frac{V_{Z1}}{V_{Z2}}$$

t_C = time in minutes to climb from altitude Z_1 in feet, to Z_2 in feet

V_{Z1} = rate of climb at altitude Z_1, fpm

V_{Z2} = rate of climb at altitude Z_2, fpm

Factor f_3 is plotted versus V_{Z2}/V_{Z1} in Fig. 22.

FUEL TO CLIMB

An approximate linear relation between the rate of fuel flow and altitude may be written as

$$w_f - w_{f1} = \frac{w_{f2} - w_{f1}}{Z_2 - Z_1}(Z - Z_1) \quad \ldots\ldots [19]$$

where w_{f1} and w_{f2} are the fuel flows in pounds per minute at altitudes Z_1 and Z_2, respectively.

The weight of fuel used during climb will be

$$W_{fC} = \int_{Z_1}^{Z_2} \frac{w_f}{V_Z}\, dz \quad \ldots\ldots [20]$$

After substituting Equations [17] and [19] into this integral, the indicated integration yields the weight of fuel in pounds required to climb from altitude Z_1 to Z_2

$$W_{fC} = \frac{Z_2 - Z_1}{V_{Z1} - V_{Z2}} \left\{ (w_{f1} - w_{f2}) + \left[w_{f1} - \frac{(w_{f1} - w_{f2})}{V_{Z1} - V_{Z2}} V_{Z1} \right] \log_e \frac{V_{Z1}}{V_{Z2}} \right\} \quad \ldots [21]$$

$$= \frac{w_{f1}}{V_{Z1}}(Z_2 - Z_1) f_4$$

where

$$f_4 = \frac{1}{1 - V_{Z2}/V_{Z1}} \left\{ 1 - \frac{w_{f2}}{w_{f1}} + \left[1 - \frac{1 - w_{f2}/w_{f1}}{1 - V_{Z2}/V_{Z1}} \right] \log_e \frac{V_{Z1}}{V_{Z2}} \right\}$$

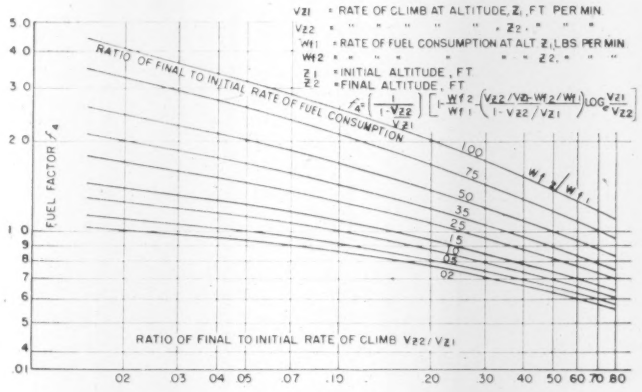


FIG. 23 FUEL USED IN CLIMB

$$\left(\text{Fuel used in pounds} = \frac{W_{f1}(Z_2 - Z_1)}{V_{Z1}} f_4.\right)$$

The factor f_4 is shown plotted versus the rate-of-climb ratio V_{Z2}/V_{Z1} and the fuel-flow ratio w_{f2}/w_{f1} in Fig. 23.

HORIZONTAL DISTANCE TRAVELED IN CLIMB

A linear relation between the true air speed and altitude may be written as

$$V_C - V_{C1} = \frac{V_{C2} - V_{C1}}{Z_2 - Z_1}(Z - Z_1) \quad \ldots\ldots [22]$$

The approximate horizontal distance in miles traveled in climbing from altitude Z_1 to Z_2 is

$$R_1 = \frac{1}{60} \int_{Z_1}^{Z_2} \frac{V dZ}{V_Z} \quad \ldots\ldots [23]$$

After substituting Equations [17] and [22] into Equation [23] and performing the indicated integration, there results

$$R_1 = \frac{Z_2 - Z_1}{60(V_{Z1} - V_{Z2})} \left\{ \left[\frac{V_{Z1} V_{C2} - V_{Z2} V_{C1}}{V_{Z1} - V_{Z2}} \right] \log_e \frac{V_{Z1}}{V_{Z2}} - (V_{C2} - V_{C1}) \right\} \quad \ldots [24]$$

$$R_1 = \frac{V_{C1}}{60\, V_{Z1}}(Z_2 - Z_1) f_5$$

where

$$f_5 = \frac{1}{1 - V_{Z2}/V_{Z1}} \left[\frac{\left(\frac{V_{C2}}{V_{C1}} - \frac{V_{Z2}}{V_{Z1}}\right)}{1 - V_{Z2}/V_{Z1}} \log_e \frac{V_{Z1}}{V_{Z2}} - \left(\frac{V_{C2}}{V_{C1}} - 1\right) \right]$$

Factor f_5 is plotted versus the ratio of velocities V_{C2}/V_{C1} and the ratios of the rates of climb V_{Z2}/V_{Z1} in Fig. 24.

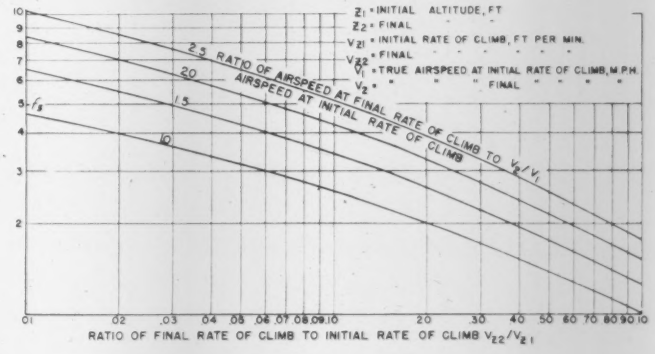


FIG. 24 HORIZONTAL DISTANCE TRAVELED IN CLIMB

$$\left(\text{Distance in miles} = \frac{V_1 (Z_2 - Z_1)}{60\, V_{Z1}} f_5.\right)$$

ANALYTICAL EXPRESSION FOR APPROXIMATE MAXIMUM RANGE

Calculation of the flight conditions yielding maximum range shows that the flight altitude should be progressively increased as the load of fuel is consumed. In order to avoid the lengthy tabular and graphical computations employed when extremely accurate calculations of range are required, a relation similar to Bregnet's formula is useful for approximate calculations with jet-propelled airplanes. One useful approximate formula can be derived by assuming that the specific fuel consumption in pounds of fuel per pound thrust per hour is a constant.

The basis of the approximate-range formula is that maximum range is obtained by flying at essentially constant true air speed; that is, as the gross weight is progressively reduced due to burning of fuel, the flight altitude is increased sufficiently to maintain a constant true air speed at reduced thrust output. The fact that the true air speed is essentially constant justifies the assumption, made previously, of constant specific fuel consumption, especially in the high-altitude region where the air temperature is constant. In other words, detailed calculations have shown that the optimum air speed for maximum range changes but little when the flight altitude is raised as the fuel load is consumed.

The fundamental equation for decrease of weight dW due to burning fuel in the time interval dt is

$$\frac{dW}{dt} = -D \times w_{fn} \quad \ldots\ldots [25]$$

where

D = required thrust for level flight, lb
w_{fn} = specific fuel consumption, lb per lb thrust per hr

The total range R_1 flown in time T is given by

$$R = \int_0^T v\,dt = \int_{W_1}^{W_2} -\frac{V\,dW}{D\,w_{fn}} = \int_{W_2}^{W_1} \frac{1}{w_{fn}} \frac{dW}{D/V} \quad [26]$$

where

W_1 = initial gross weight, lb
W_2 = final gross weight, lb
$= W_1 - W_f$
W_f = weight of fuel consumed, lb

If the specific fuel consumption w_{fn} is assumed constant, it can easily be shown that the minimum value of D/V, and hence of maximum range, occurs at an airplane speed of

$$V_{MR} = \frac{19.55}{\sigma^{1/2}} [l_p \times l_s]^{1/4} \quad [27]$$

where

V_{MR} = air speed at maximum range, mph

(the subscripts MR denote conditions yielding maximum range)

$l_p = \frac{W}{f} = \frac{W}{C_{DP_e} S}$ = effective parasitic loading, psf

$l_s = \frac{W}{eb^2}$ = effective span loading, psf

C_{DP_e} = effective parasitic drag coefficient

S = wing area, sq ft

The lift-drag ratio at speed for maximum range of jet-propelled aircraft then becomes, assuming no variation in specific fuel consumption with speed

$$\left(\frac{L}{D}\right)_{MR} = 0.767 \frac{b_e}{f^{1/2}} = 0.865 \left(\frac{L}{D}\right)_{\max} \quad [28]$$

For propeller-driven aircraft, the speed for maximum range occurs very near the speed for maximum lift-drag ratio

$$\left(\frac{L}{D}\right)_{\max} = 0.886 \frac{b_e}{f^{1/2}} \quad [29]$$

To summarize thus far, the speed for best range of a jet-propelled airplane is about 30 per cent greater, and the drag about 15 per cent greater than the corrresponding speed and drag for best range of the same airplane powered with conventional engine and propellers.

At the speed of maximum range, the parasitic drag is approximately 3 times the induced drag for the jet-propelled aircraft. These two components of drag are nearly equal in propeller-driven aircraft.

The minimum value of $\frac{D}{V}$ in pounds per mile per hour is then

$$\left(\frac{D}{V}\right)_{\min} = 0.0667 \sigma^{1/2} \frac{f^{3/4}}{b_e^{1/2}} \times W^{1/2}$$

where

f = equivalent parasite area, sq ft
b_e = effective span of wing, ft
W = gross weight of airplane, lb

Introducing the foregoing relations plus Equation [15] into Equation [26], and completing the required integration, yields an approximate formula for range after completion of initial climb

$$R_{\max} = \frac{14.80}{w_{fn}} \left[\frac{\phi_{avg} F_0}{f}\right]^{1/2} \left(\frac{L}{D}\right)_{\max} \log_e \frac{W_1}{W_2} \quad [30]$$

where

$R_{\max}$ = maximum range after initial climb, miles
w_{fn} = average specific fuel consumption during trip, lb of fuel per pound thrust per hour
ϕ_{avg} = average value of thrust factor during flight
W_1 = gross weight at beginning of level flight, lb
W_2 = gross weight at end of level flight, lb
f = equivalent parasite area, sq ft
$(L/D)_{\max}$ = maximum value of lift-drag ratio

An alternate form for the range R is

$$R_{\max} = \frac{13.1}{w_{fn}} (\phi_{avg} F_0)^{1/2} \times \frac{b_e}{f} \times \log_e \frac{W_1}{W_2} \quad [31]$$

An alternate derivation yields a maximum-range formula involving the constant air speed V_{MR} for maximum range.

Equation [27] may be rewritten as

$$\left.\begin{aligned} V_{MR} &= \frac{19.55}{\sigma^{1/2}} [l_p l_s]^{1/4} \\ &= \frac{19.55}{\sigma^{1/2}} \frac{W^{1/2}}{f^{1/4} b_e^{1/2}} \end{aligned}\right\} \quad [32]$$

From Equation [28]

$$\left(\frac{L}{D}\right)_{MR} = 0.767 \frac{b_e}{f^{1/2}}$$

$$\left(\frac{D}{L}\right)_{MR} = 1.305 \frac{f^{1/2}}{b_e}$$

$$D_{MR} = 1.305\, W \frac{f^{1/2}}{b_e} \quad [33]$$

By definition of the thrust function

$$\phi = \frac{F_n}{\sigma F_0}$$

$$\sigma = \frac{F_n}{\phi F_0}$$

$$\sigma^{1/2} = \frac{F_n^{1/2}}{(\phi F_0)^{1/2}} \quad [34]$$

Combining the foregoing equations results in

$$\sigma^{1/2} = (1.305)^{1/2} \frac{W^{1/2} f^{1/4}}{(\phi F_0)^{1/2} b_e^{1/2}} \quad [35]$$

since for level flight $F_{MR} = D_{MR}$.

Substituting Equation [35] into Equation [32] yields

$$V_{MR} = 17.15 \left[\frac{\phi F_0}{f}\right]^{1/2} \quad [36]$$

This formula shows that the true air speed is constant so long as the thrust function ϕ is constant. With this condition, the integration of Equation [26] can be made directly

$$R_{\max} = \int_{W_2}^{W_1} \frac{V\,dW}{w_{fn} \times D} = \frac{V_{MR}}{w_{fn}} \left(\frac{L}{D}\right)_{MR} \int_{W_2}^{W_1} \frac{dW}{W}$$

$$= \frac{V_{MR}}{w_{fn}} \left(\frac{L}{D}\right)_{MR} \times \log_e \frac{W_1}{W_2} \quad [37]$$

$$= 0.865 \frac{V_{MR}}{w_{fn}} \left(\frac{L}{D}\right)_{\max} \times \log_e \frac{W_1}{W_2} \quad [38]$$

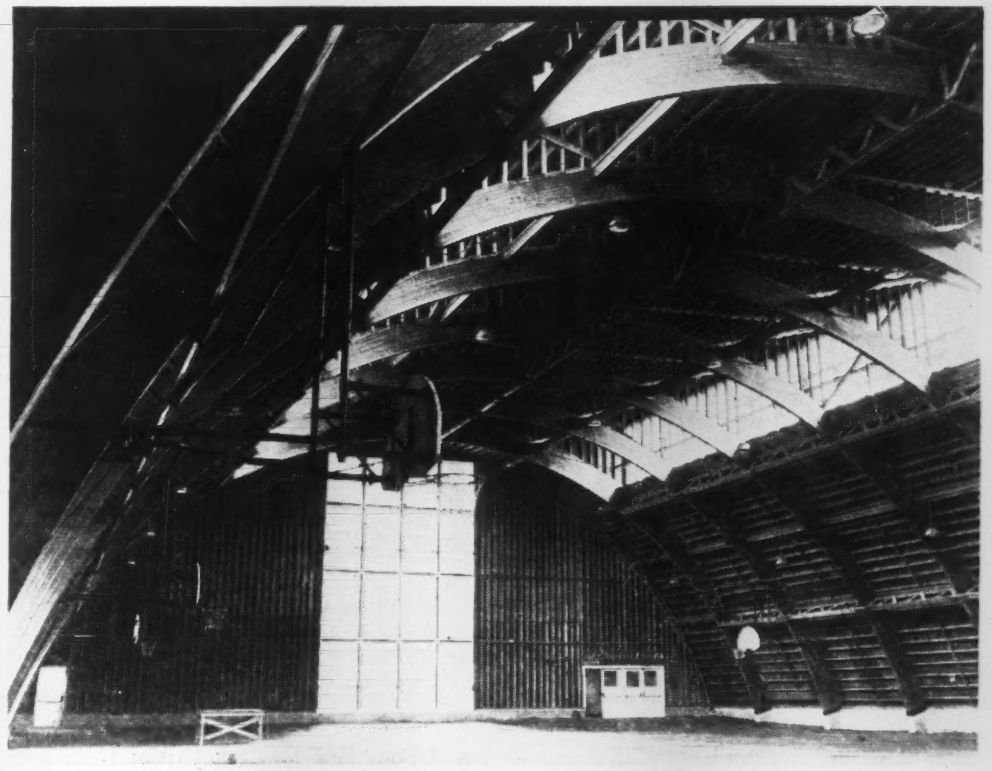


FIG. 1 DRILL HALL UNITED STATES COAST GUARD ACADEMY, NEW LONDON, CONN.

GLUED-LAMINATED ARCHES *With* SAWED LAMINATIONS

By LIEUT. COMMANDER E. A. DUBIN (T)

CHIEF OF STRUCTURAL ENGINEERING, U. S. COAST GUARD, WASHINGTON, D. C.

EXPERIENCE resulting from emergency expedients for solving material shortages and other problems during the war has greatly extended previous engineering and construction knowledge. It is believed that the experience of the United States Coast Guard with sawed-face lumber for glued-laminated wooden-arch construction merits its consideration for peacetime use.

The Coast Guard Academy, at New London, Conn., is a completely equipped school for training officers for the Regular Coast Guard. Upon completion of a four-year course at the Academy, the cadets are awarded a bachelor of science degree and commissioned as ensigns in the Coast Guard. The permanent plant at the Academy, built in 1932, and expanded in 1941, has facilities to accommodate about 350 cadets. These include the cadet barracks, mess hall, library, hospital, academic building, lecture hall, shops, laboratories, administration building, armory, gymnasium, etc., all of colonial Georgian architecture.

After the outbreak of the war, additional temporary facilities for training and housing a large number of reserve-officer candidates were required. Additional buildings, of wooden frame construction, were designed by Arthur Deimel, architect, of New London, under the direction of Coast Guard Headquarters, Office of Engineering. Rear Admiral Harvey F. Johnson is Engineer in Chief, and Captain R. R. Tinkham is Chief of the Civil Engineering Division. The additional facilities constructed accommodate 1056 men and include four barracks buildings, a mess hall, an academic building, an auditorium, a drill hall, and an administration building. The reserve cadet school was substantially completed on May 22, 1943, and the buildings have been occupied since that date.

The drill hall, Fig. 1, is an unheated building 100 ft wide and 151 ft long. Nine arches, spaced 15 ft on center, support the roof. They are composed of 36 laminations, 1-in. × 8-in. West Coast Douglas fir, have a cross section $7^1/_2$ in. × $28^1/_8$ in., an outer radius of 51 ft $4^{15}/_{16}$ in., and a rise of 40 ft from floor to crown. All surfaces joined by gluing, except scarf joints, were planed. The arches were constructed in halves and designed as three-hinged arches to support the roof designed for a live load of 30 psf of horizontal projection, and a wind load of 20 psf. Design and fabrication of the arches was by Rilco Laminated

Contributed by the Wood Industries Division and presented at the Annual Meeting, New York, N. Y., Nov. 26-29, 1945, of THE AMERICAN SOCIETY OF MECHANICAL ENGINEERS.

NOTE: The opinions expressed in this paper are those of the author and not necessarily those of the Navy Department or Coast Guard.

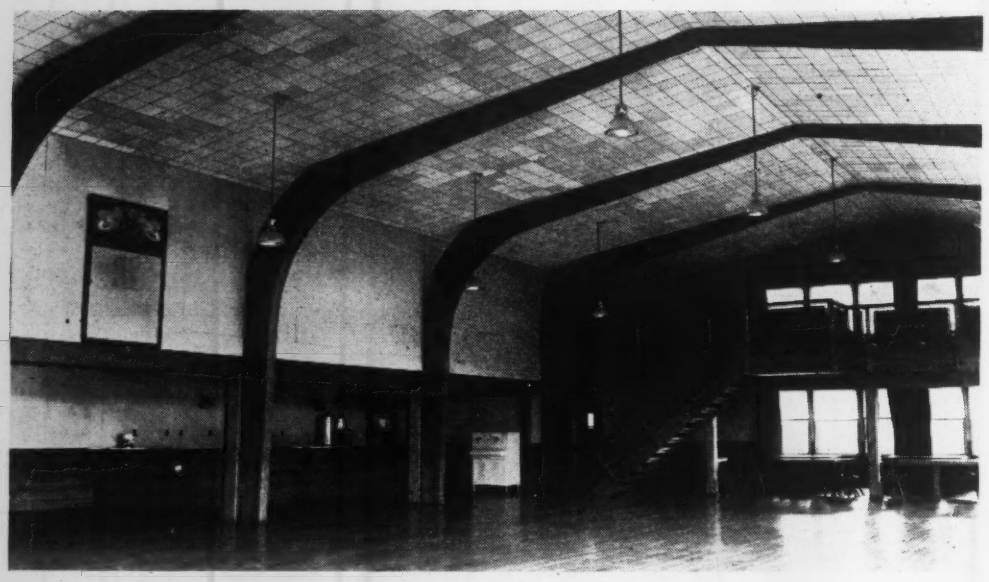


FIG. 2 GROUP INSTRUCTION ROOM, ADMINISTRATION BUILDING

Wood. Clear Douglas fir (coast region) weight 35 lb per cu ft { 12 per cent moisture content before gluing. / 16.6 ± per cent moisture content after gluing.
Laminations. $^{11}/_{32}$ ± in. thick. Resawed from $^{3}/_{4}$-in. × $7^{1}/_{2}$-in. stock. One face planed, one face sawed.
Glue. Casein mix: 18 lb glue to 30 lb water. 8 ± lb glue per 100 sq ft. Spread with Black Bros. double-roll spreader.

Products, Inc., Wilkes-Barre, Pa., in accordance with specifications for Grade I construction (1).[1]

The administration building, heated by direct steam radiation, has a group instruction room, Fig. 2, the main portion of which is 47 ft 4 in. wide × 80 ft long. The roof and ceiling of this room are supported on four "boomerang" arches spaced 16 ft on center. These arches are constructed in halves and designed as three-hinged arches for the same live and wind loads as the drill-hall arches. These arches have a span of 47 ft 4 in. out to out, a rise of 22 ft $2^{1}/_{2}$ in. from the floor to the apex, and are bent to a radius of 7 ft at the knee. The cross section of the arch is 7 in. × $14^{13}/_{16}$ in. at the base, 7 in. × $27^{1}/_{4}$ in. at the knee, and 7 in. × $8^{9}/_{16}$ in. at the apex. Laminations are Coast Region Douglas fir $^{11}/_{32}$ in. ± thick. These arches were also designed and fabricated by Rilco Laminated Products, Inc., to the same specification as the drill-hall arches, but the laminations, after resawing from $^{3}/_{4}$-in. × $7^{1}/_{2}$-in. stock, were not machined. All joints between laminations have one planed and one sawed surface.

The arches have been subjected to two winters in service, during which 6-in. snowfalls have been measured on the roofs. In September, 1944, a hurricane struck New England. Weather Bureau reports (2) from the nearest station, Fishers Island, about 8 miles from New London, indicate a 78-mph wind for a 5-min duration, and an extreme gust velocity of 96 mph. Wind-velocity readings at the Academy indicate a wind of about 63 mph. This latter reading was obtained in a sheltered portion of the Academy grounds and does not represent the wind velocity at the site of the administration building or drill hall which are in a very exposed location on a bluff overlooking the Thames River.

TESTS OF GLUED-LAMINATED BEAMS FABRICATED WITH LAMINATIONS, SAWED ONE FACE AND PLANED ONE FACE

After the design of the arches was approved by the Coast Guard, the fabricator had the material for the boomerang arches for the administration building resawed from $^{3}/_{4}$-in. × $7^{1}/_{2}$-in. finished stock. It was contemplated that the sawed surfaces would be planed for use in the arches. After resawing, the laminations were approximately $^{11}/_{32}$ in. thick. Planing would have increased greatly the number of laminations required, wasted considerable material, and entailed a delay necessary to permit procurement of additional stock.

The fabricator requested permission to use the laminations with one sawed face. Samples of arch ribs for small farm buildings having sawed-face laminations, regularly manufactured by the fabricator, showed neat thin glue joints. Inspection of the resawed laminations for the boomerang arches indicated that the sawed surfaces were generally smooth, although some sawed faces had rough torn grain. The laminations were generally each of uniform thickness, but all laminations were not of the same thickness. Before granting approval for the use of sawed-face laminations, a sample beam was fabricated and tested.

Sample Beam. Eight laminations were chosen, three with badly torn grain and five with well-sawed faces. They were scarfed and spliced, brushed with a wire brush before spreading glue, and assembled into a sample beam, as indicated in Fig. 3. At the time of assembly of the sample beam, the shop was fabricating several large glued-laminated beams for use on another project. The laminations for the sample beam were turned over to the crew fabricating the stock beams to spread the glue and place the laminations in the clamps, as indicated in Fig. 4. The clamps, spaced 16 in. on center, were adequate for the stock beam having laminations nominally 1 in. thick. This spacing was, however, excessive for the sample beam, with $^{11}/_{32}$-in-thick laminations. After $10^{1}/_{2}$ hours the sample beam was removed from the clamps and cut into six test specimens, as shown in Fig. 3. The time in the clamps was $1^{1}/_{2}$ hr less than the minimum recommended by the Forest Products Laboratory (1). The glue joints at the laminations having torn grain were thick and uneven. All other joints were of good appearance.

STATIC BENDING TESTS OF SPECIMENS CUT FROM SAMPLE BEAM

Laboratory facilities for testing the specimens were not available in the plant, but a rig, as illustrated in Fig. 5, was assembled. Specimens 1, 2, 3, 5, and 6 were tested to failure. Load and deflection readings were taken at frequent intervals. Calibration of the dynamometer after completion of the tests indicated that load readings were unreliable and they were dis-

[1] Numbers in parentheses refer to the Bibliography at the end of the paper.

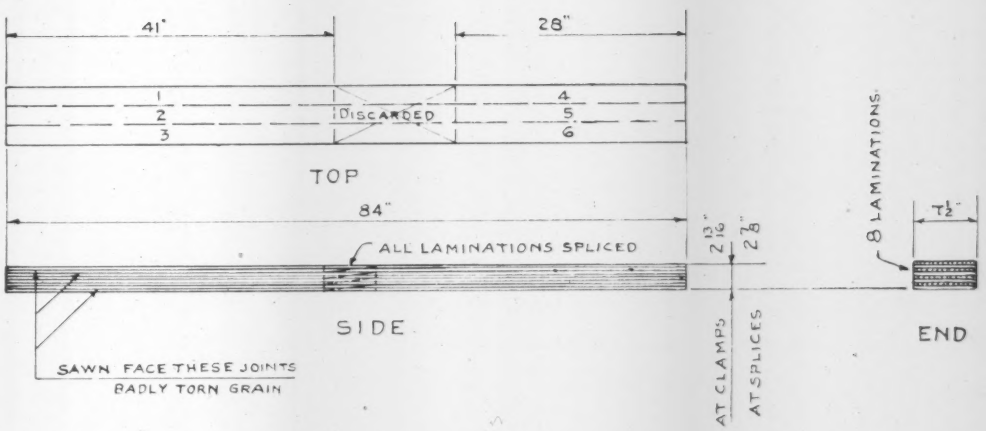


FIG. 3 DETAIL OF SAMPLE BEAM

Wood. Clear Douglas fir (coast region) weight 35 lb per cu ft { 12 per cent moisture content before gluing. / 16.6 ± per cent moisture content after gluing.

Laminations. $^{11}/_{32}$ ± in. thick. Resawed from $^{3}/_{4}$-in. × $7^{1}/_{2}$-in. stock. One face planed, one face sawed. Top two laminations and bottom lamination chosen for badly sawed face with rough torn grain. Sawed face of other laminations free of torn grain.

Glue. Casein mix: 10 lb glue to 20 lb water. 8 ± lb glue per 100 sq ft. Spread with Black Bros. double-roll spreader 9:00 p.m., March 24, 1943; clamped 9:05 p.m., March 24, 1943; clamps removed 7:30 a.m., March 25, 1943; time in clamps $10^{1}/_{2}$ hr.

Test Specimens. Test specimens 1–6, inclusive, were cut from sample beam as indicated in top view and dressed to 2-in. width. Specimens 4–6, inclusive, were dressed to a depth of $1^{3}/_{4}$ in. after removal of the two top and one bottom lamination.

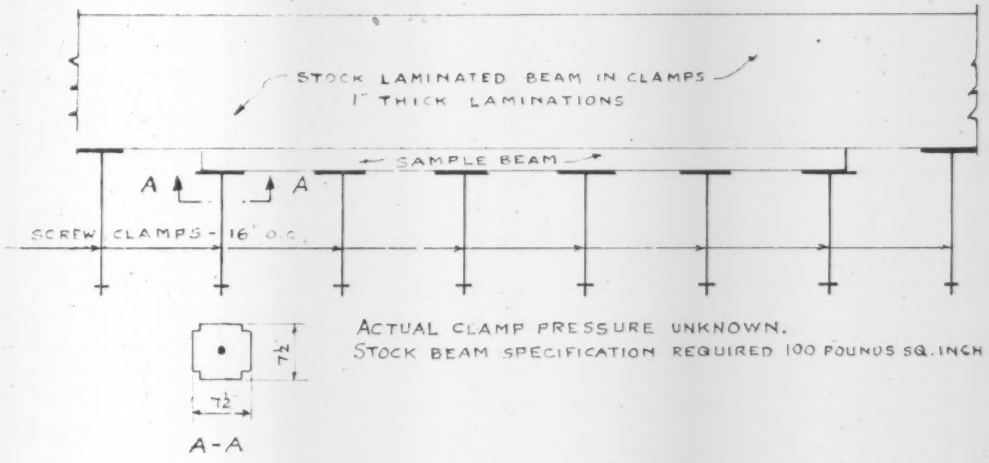


FIG. 4 DETAIL OF SAMPLE BEAM IN CLAMPS

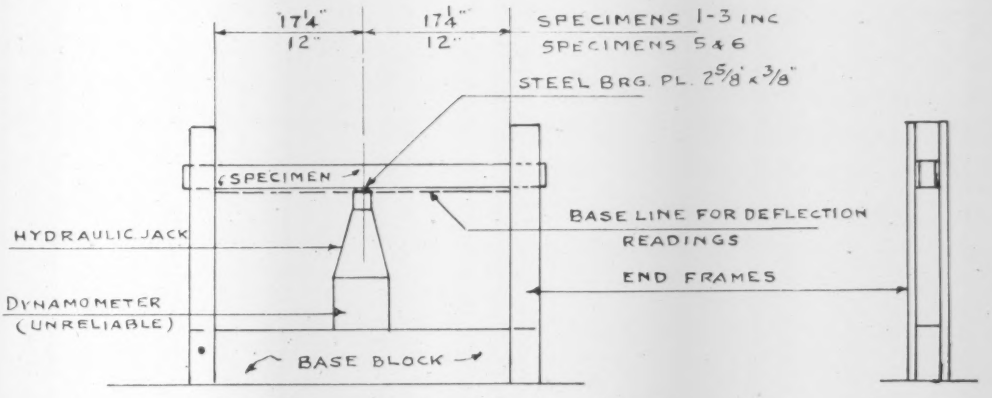


FIG. 5 SCHEMATIC ARRANGEMENT OF TESTING RIG

carded. T. R. C. Wilson, acting director of the Forest Products Laboratory, advised that it can be expected that the strength and stiffness of well-glued laminated beams is approximately the same as the strength and stiffness of solid beams of equivalent grade, density, and moisture content.

The moisture content of the laminations, as determined by a moisture meter, was 12 per cent before gluing. Facilities were not available for determining the moisture content of the sample beam after gluing. However, on the assumption of all the water in the glue being absorbed by the wood, the moisture content of the specimens would be not more than 16.6 per cent. Using this value for the moisture content and the method recommended by the Forest Products Laboratory[2] for moisture-strength adjustment, the physical properties of the glued specimens were computed to be as follows:

Proportional limit	= 6650 psi
Modulus of rupture	= 9940 psi
Modulus of elasticity	= 1,760,000 psi

[2] Bibliography (3), Table 1, pp. 50–57.

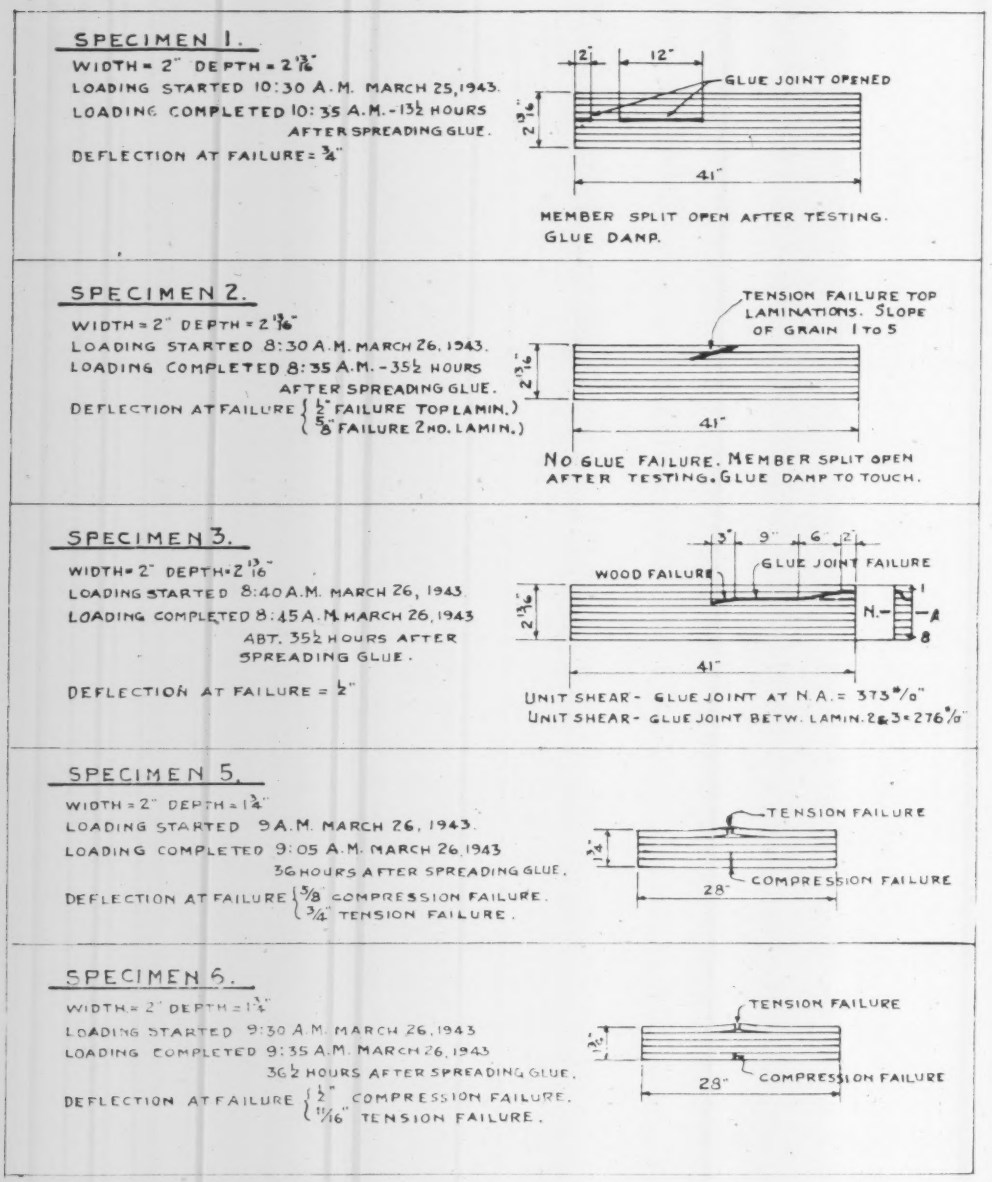


FIG. 6 TEST SPECIMENS

For these computed values, the physical dimensions of the specimens, the span, and the method of loading, the stress-strain diagrams, Figs. 7 (*a*) and (*b*), were drawn. These are based on the curves for typical stress-strain diagrams for Douglas fir at 12 and 31.4 per cent moisture content.

Data relative to the loading tests, for specimens 1, 2, 3, 5, and 6, are shown in Fig. 6. Fig. 7 (*a*) represents a load-deflection diagram on which the failures of specimens 1, 2, and 3, are plotted, and Fig. 7 (*b*) represents a load-deflection diagram on which the failures of specimens 5 and 6 are plotted. Specimen 4 was not tested. Test results are given in Table 1.

Although the method of testing was crude, and certain assumptions were made to determine the indicated loads and the computed shears developed in the glue joints, it is believed that these values are of the proper order. From these data it appears:

(*a*) Glued joints with laminations having rough torn grain on the sawed face are unreliable; failure at about 275 psi occurred in such a joint for specimen 3.

(*b*) Glued joints with laminations having a well-sawed face developed at least 348 psi without any evidence of failure; and, except for specimen 1 (which had damp glue) no such glue joint failed in shear under the test loads.

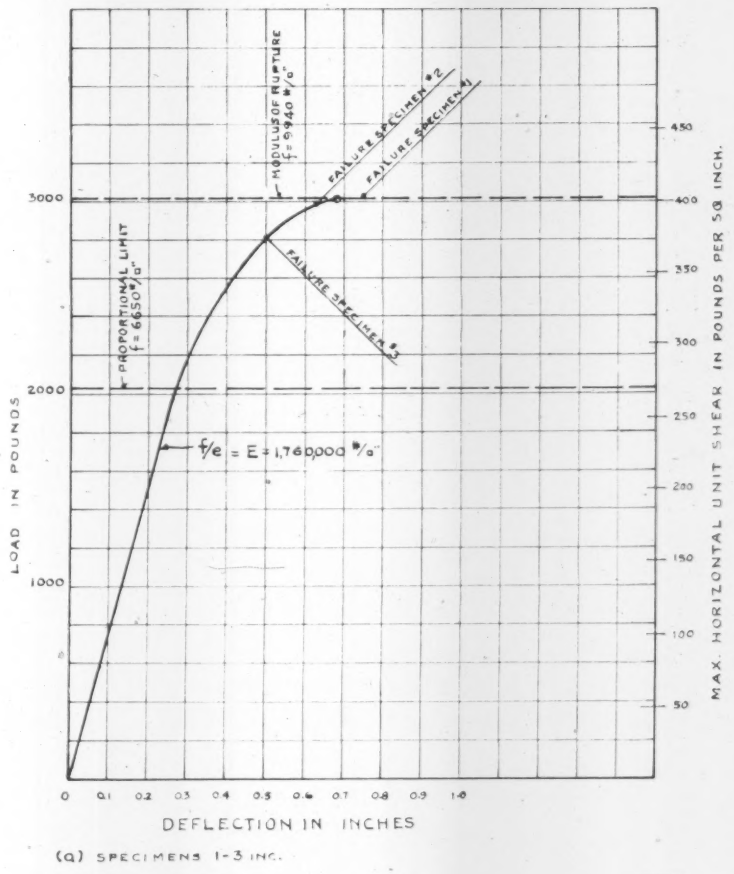
BOOMERANG ARCHES FOR ADMINISTRATION BUILDING

As a result of the tests, permission was granted to use laminations for the boomerang arches having one sawed face. It was stipulated that all sawed faces were to be well sawed, free of rough torn grain, and brushed clean of sawdust, and each lamination was to be of uniform thickness. A glue mix of 18 lb of casein glue to 30 lb of water was established, and the clamps were spaced not over 12 in. on center, in lieu of 16 in. as used for the test beam, to provide more uniform clamping pressure.

Inspection reports on the boomerang arches after 28 months in service, including two winters and a hurricane, indicate:

(*a*) No checking has occurred.
(*b*) There is no evidence of any glue joint opening.
(*c*) The appearance of all arches is very good. With the exception of one arch, where fabrication was substandard, these arches have neat thin glue joints.

The latest inspection of these arches was made in September, 1945.



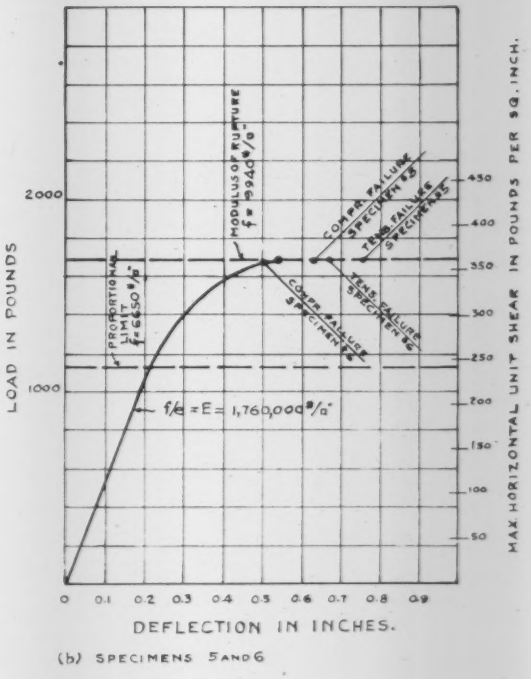


FIG. 7 ASSUMED LOAD-DEFLECTION DIAGRAMS IN STATIC BENDING, GLUED-LAMINATED SPECIMENS WITH LAMINATIONS PLANED ONE FACE, SAWED ONE FACE
(Based on typical load-deflection diagram for coast region Douglas fir having moisture content 16.6 per cent.)

Fig. 9 is a close-up view of a typical "boomerang" arch. Fig. 10 is a close-up view of the base of a typical drill-hall arch, which has planed laminations. It will be noted that the appearance of the boomerang arch, shown in Fig. 9, compares favorably with the appearance of the drill-hall arch, Fig. 10.

Fig. 11 indicates the defects in workmanship appearing on one boomerang arch. The outer laminations were badly marred by rough handling. Thick glue joints marked *A* are apparently due to rough-sawed faces of the laminations inadvertently included, plus variation in thickness of the laminations. Joint marked *B* is a hand-planed joint between the outer section having parallel laminations and the tapered center core of the arch; *C* indicates a poor scarfed joint. It is reported that none of these are open joints but are thick glue joints with the glue line slightly back of the face of the arch. During the period these arches were being fabricated, drafting of labor for the Armed Forces made it difficult to maintain skilled crews of workmen. It is believed that this factor contributed materially to such defects of workmanship as developed in the fabrication of these arches.

DATA ON GLUED JOINTS FROM OTHER SOURCES

The Forest Products Laboratory, U. S. Department of Agriculture, through some of its publications (1, 3, 4, 5), has presented essentially complete data for design, fabrication, and construction with wood. The bulletin on the "Glued-Laminated Wooden Arch," by T. R. C. Wilson (1), is a classical study of glue-laminated structural members, wherein the advantages of such construction, together with elaborate experimental data and recommendations for the design and fabrication of these members, are presented. A section of the proposed "National Design Specification for Stress-Grade Lumber and Its Fastenings" (6), recommended by the National Lumber Manufacturers' Association, is devoted to the design and fabrication of glued laminated structural members. The essential require-

TABLE 1 TEST RESULTS

Specimen no.	Maximum deflection, in.	Maximum indicated load lb	Computed maximum shear stress in glue joint, psi	Remarks
1	3/4	3010	400	Glue failure; glue not set
2	5/8	2980	398	Failure of wood in tension; no shear failure
3	1/2	2800	373	Failure of glue joint between upper two laminations at joint having sawn face with rough torn grain, at computed shear stress of 276 psi. No indication of shear failure in glue joint at neutral axis
5	5/8 (Compression) 3/4 (Tension)	1685	348	Failure of laminations in tension and compression at indicated stress of 9940 psi. No shear failure in glue joints
6	1/2 (Compression) 11/16 (Tension)	1685	348	Failure of laminations in tension and compression at indicated stress of 9940 psi. No shear failure in glue joints
			Average 373	

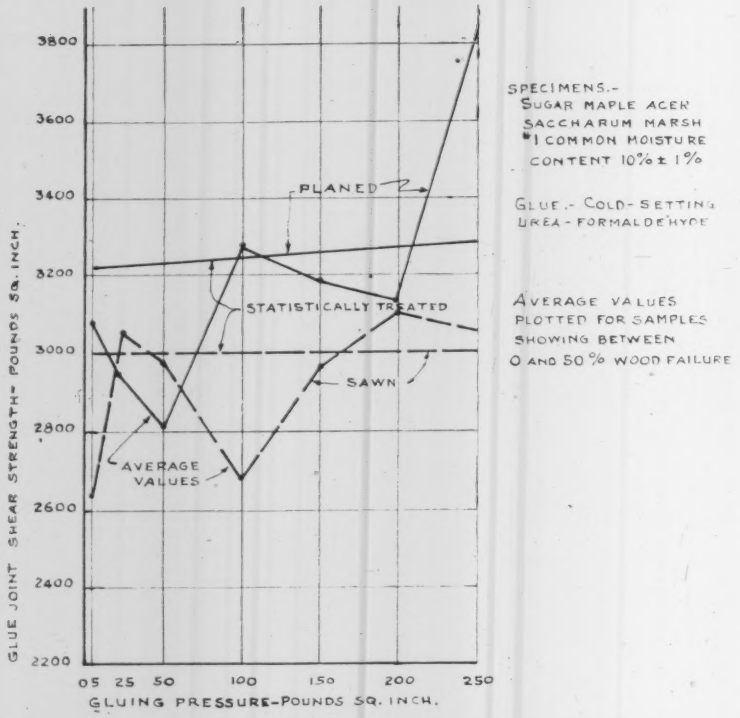


FIG. 8 VARIATION IN STRENGTH OF GLUED JOINTS FOR PLANED AND SAWN SURFACES WITH VARIATION OF GLUING PRESSURE
(From Bibliography reference 7, pp. 14–15.)

ments for strong glued members are well established;[3] the glue must be suitable, properly mixed, and properly spread; the wood must be clean and it must be surfaced smoothly enough to provide full contact between adjacent laminations; the moisture content of the adjacent laminations should be practically uniform and such that, including the moisture absorbed from the glue, the member will have a moisture content about the same as it will have in service; the laminations should have the same shrinkage properties; the assembly time, room temperature, and pressure maintained on the assembly must suit the glue used, etc. The type of surfacing of the laminations in a glued-up structural member is only one of many factors determining the strength of the member. Experience indicates that proper gluing technique is all-important and that regardless of what type of surfacing is used for laminations in glued-up structural members, poor gluing technique will result in weak or defective glue joints. The Forest Products Laboratory recognizes that glued joints of approximately equal strength may be made between two planed or smoothly sawed surfaces.[4] Data presented in a recent study by the New York State College of Forestry, at Syracuse University,[5] confirms this, although this conclusion was not drawn by the author.

Animal Glue. The shear strength of glued joints made with animal glue under unregulated temperature conditions for 201 curved-arch members, tested at the Forest Products Laboratory, is given in Table 2. These arch members, of $^3/_4$-in-thick laminations of southern yellow pine, were approximately 6 in. wide by 6, 9, and 13 in. deep, respectively; chord lengths varied from 14 to 15 ft. The laminations were prepared for gluing by carefully machining the faces.[6]

The gluing pressure used in fabricating the assemblies, Table 2, was not stated. If the gluing pressure ranged between 100 and 200 psi, as is recommended by the Forest Products Laboratory, the following strengths should result for the glue joints under controlled temperatures and proper assembly:[7]

Temperature of room and wood, deg F	Average shear strength, psi	Minimum value, psi
90	2800	1700
70	2500	1350

Tests of small clear specimens of wood 2 in. × 2 in. in cross section[8] indicate that for southern yellow pines the average shear strengths range from 1310 to 1500 psi.

The five failures, Table 2, entirely within the glue joint, occurred at shear values of 12 to 18$^1/_2$ per cent of the minimum glue-joint strength and 6$^1/_2$ to 10 per cent of average glue-joint strength for controlled temperatures of 70 F, and developed only 12.3 to 19 per cent of the minimum shear strength of the wood. The maximum shear value of 786 psi obtained, Table 2, for members where primary failure was shear, developed only 58 per cent of the minimum glue-joint strength and 31$^1/_2$ per cent of the average glue-joint strength, for controlled temperatures of 70 F, and developed only 60 per cent of the minimum value for the shear strength of the wood.

From the foregoing it is apparent that glue-joint strength is drastically affected by gluing technique, and that shear strengths of wood, as determined for small clear specimens, are considerably reduced for large structural members.

TABLE 2 SHEAR VALUES FOR CURVED LAMINATED MEMBERS OF SOUTHERN YELLOW PINE, GLUED WITH ANIMAL GLUE[b]

Number of members	Computed shear, psi	Remarks
8[a]	162–249	Primary failure in shear
21	250–786	
5	Less than 160	Shear values attained at the time the member failed from other causes
45	160–250	
77	250–350	
45	350–720	
Total 201	Average = 354	

[a] Five failures entirely in glue line.
[b] Bibliography (1), p. 56.

TABLE 3 EFFECT OF GLUING PRESSURE ON JOINT STRENGTH OF HARDWOODS GLUED WITH CASEIN GLUE[a]

Gluing pressure, psi	Average shear strength, psi	Average wood failures, per cent
50	1850	56
100	1925	62
200	1950	66
375	1950	66

[a] Each value represents at least 756 specimens.

Casein Glue. The effect of gluing pressure on joints of 19 hardwood species, in which casein glue was used, is shown in Table 3,[9] as determined by the Forest Products Laboratory.

The strength of glued joints, as determined by shear-block tests, for southern yellow pine and Douglas fir, glued with casein glue under 200 psi pressure, is given by the Forest Products Laboratory,[10] as listed in Table 4.

Tests of curved-laminated members for longitudinal shear under transverse loading were also made by the Forest Products Laboratory.[11] Parabolically curved members 20 ft long, measured along the chord and composed of 12$^3/_4$-in. × 5-in.

[3] Bibliography (5); (6), sections 901, 903, 904.
[4] Bibliography (4), p. 172.
[5] Bibliography (7), pp. 13–15, 23.
[6] Bibliography (1), pp. 14 and 16.
[7] Bibliography (5), Fig. 8, p. 38.
[8] Bibliography (4), Table 8, p. 53.
[9] Bibliography (5), Fig. 9, p. 39.
[10] Bibliography (1), Table 28, p. 82; Table 29, p. 83
[11] Bibliography (1), pp. 83–86.

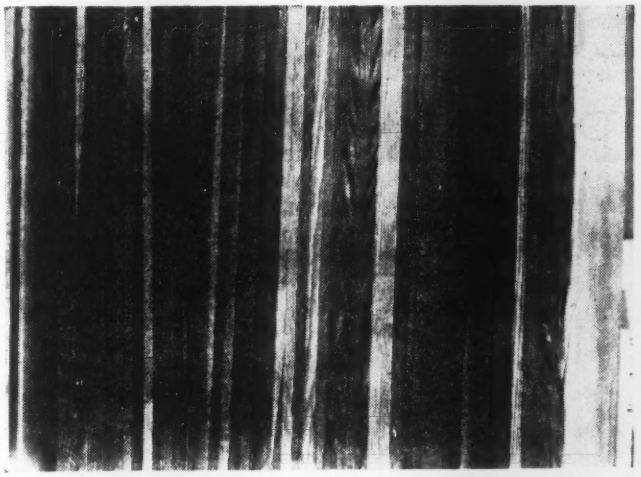


FIG 9 BOOMERANG ARCHES, ADMINISTRATION BUILDING

FIG. 10 LAMINATED ARCHES, DRILL HALL

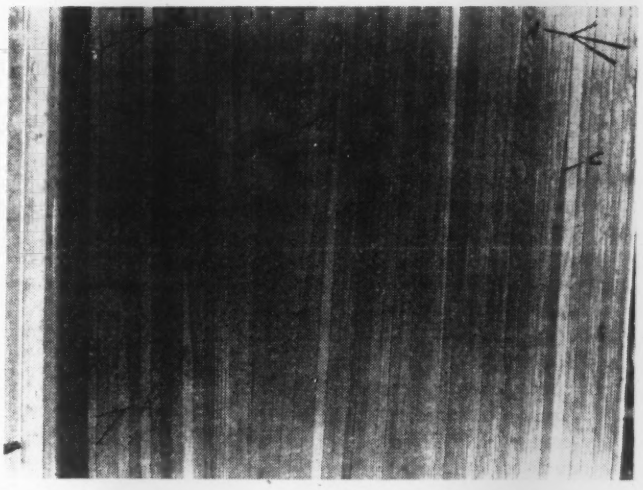


FIG. 11 CLOSE-UP VIEW OF ONE OF THE BOOMERANG ARCHES SHOWING DEFECTS IN WORKMANSHIP

TABLE 4 GLUE-JOINT STRENGTH FOR SOUTHERN YELLOW PINE AND DOUGLAS FIR[a]

	Southern yellow pine		Douglas fir	
Assembly[b]	Shear, psi	Per cent wood failure	Shear, psi	Per cent wood failure
A	1170	98	1269	93
B	1171	86	1245	100
C	1186	100	1091	94
D	1170	96	1181	76
E	1661	88	1245	91
F	1543	99	1468	94
G	1375	75	1422	94
H	1472	71	1439	78
Average	1343	89	1295	90
Minimum	1 at 800–849	...	2 at 950–999	...

[a] Casein glue used. Pressure applied, 200 psi.
[b] Values are average of 6 specimens from each assembly.

laminations with machined surfaces, were glued with casein glue. The six central laminations were southern yellow pine and the outer laminations were Douglas fir. These members were cut into shorter test specimens. The results for the specimens tested with the convex side down (to eliminate the effect on the longitudinal shear values of the radial tension stress present in those members tested with the convex side up) are listed in Table 5. The span for the tests was 7 ft, with equal transverse loads placed $1^1/_2$ ft each side of the center line.

The shear strength indicated for the members tested for longitudinal shear under transverse loading, Table 5, is less than 50 per cent of the average shear strength of the wood,[12] about 50 per cent of the average shear strength developed in the shear block tests, Table 4 (in which wood failure governed), and about 35 per cent of the glue-joint strength, Table 3, for gluing pressure varying from 100 to 200 psi.

TABLE 5[a] LONGITUDINAL SHEAR TESTS UNDER TRANSVERSE LOAD FOR CURVED ASSEMBLY CONVEX SIDE DOWN, OF DOUGLAS-FIR AND SOUTHERN-YELLOW-PINE LAMINATIONS GLUED WITH CASEIN GLUE; GLUED SURFACES MACHINED

Specimen	Maximum load, lb	Computed shear stress, psi	Remarks
312A	46040	670	Tension failure; no shear
314A	46000	670	95+ per cent wood failure

[a] Bibliography (1), Table 30, p. 85.

Variations in Strength of Glue Joints as Affected by Wood Surface. A study of the shear strength of glue joints, as affected by wood surfaces and glue pressures, has been made by the New York State College of Forestry (7). Tests were made for gluing pressures varying from 5 to 250 psi, with specimens of sugar maple having planed, sawed, sanded, burnished, and combed surfaces. The results of these tests for sawed and planed surfaces only are shown in Fig. 8. From Fig. 8 it is apparent that for

(*Continued on page 838*)

[12] Shear strength of wood, 1310 to 1500 psi.

VISCOSITY *of* LUBRICANTS *Under* HIGH PRESSURE

Co-ordinating the Data From Ten Investigations

By MAYO D. HERSEY[1] AND RICHARD F. HOPKINS[2]

RESEARCH on properties of lubricants under high pressure has been sponsored by the A.S.M.E. Special Research Committee on Lubrication since 1915. The original object was to help explain oiliness phenomena (5, 7).[3] Applications to the cutting and forming of metals, as well as bearing and gear lubrication, were constantly kept in view.

FRICTION AND FILM THICKNESS

The relation of the increase in viscosity under pressure to friction and film thickness has been further investigated by Stanton, Weibull, Karlson, and others (8, 9, 11, 12, 28–30, 33, 35, 41, 42, 48). All these references are valuable to the student of lubrication. A novel point of view was introduced by Everett (33) in discussing Bradford and Wetmiller's experiments. Professor Everett traced out "the private life of the oil particle," as it passes through the film, experiencing a succession of pressure and temperature changes.

Fig. 1 illustrates some of the conclusions from Needs' investigation (35). The upper curve, showing a pronounced minimum point on the coefficient-of-friction diagram, was calculated for a petroleum oil having a fairly high value, 23.4 per cent per 100 atm, for the pressure coefficient of viscosity. The "atmosphere," or kilogram per square centimeter, has been the pressure unit most commonly employed in high-pressure research. It is approximately equal to 14.2 psi. The curve marked 14.3 is for castor oil and the next lower for glycerin. These calculations show how the shape of the curve is influenced by the pressure coefficient, or fractional increase in viscosity per unit increase of pressure. Therefore, since the pressure coefficient has been found to be greater for petroleum than for fatty oils, it is to be expected that, in heavily loaded bearings, a petroleum oil will offer more friction than a fatty oil of equal viscosity at atmospheric pressure. These calculations were beautifully confirmed by tests on partial journal bearings such as might be applied to roll necks. The complete paper should be consulted for further particulars.

Fig. 2 shows how the film thickness h_o between gear teeth is affected by changing from one lubricant to another of equal viscosity Z_1 at atmospheric pressure, but having about twice the pressure coefficient. Suppose, for example, that a fatty oil with pressure coefficient b_1 at atmospheric pressure equal to 10 per cent per 100 atm is replaced by a petroleum oil with b_1 = 21.5 per cent. Expressed in reciprocal pounds per square inch, the first coefficient is equal to 7.05×10^{-5} and the second to 15.1×10^{-5}. Let the tooth load per unit face width and unit of pitch diameter be P = 13,200 psi or, say, 28,400 lb per in. width for a 2-in-diameter pinion. The dimensionless parameter b_1P is then equal to 0.93 for the fatty oil, and to 2 for the petroleum oil, as marked on the curves. Now compare the film thickness for a fixed value of Z_1N/P equal to 60, where Z_1 is in newtons (or millionths of a pound-second per square inch), N in rpm, and P in psi. The relative film thickness h_o/D is given here in microinches per inch of pitch diameter. The theoretical film thickness for the fatty oil is, therefore, 3.6 × 2 or

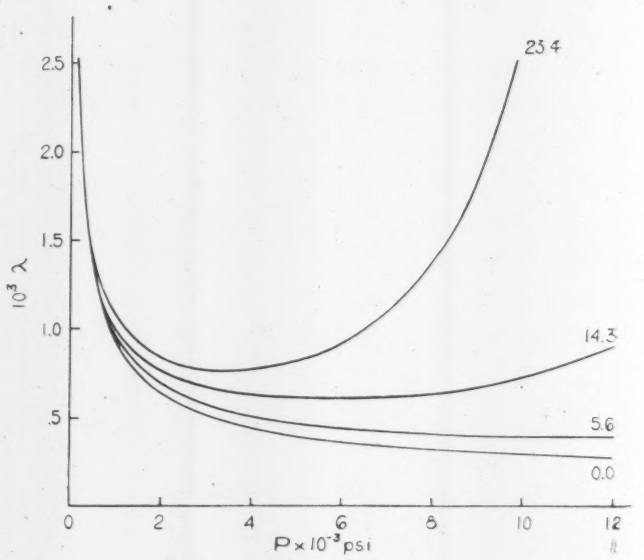


FIG. 1 CALCULATED FRICTION COEFFICIENT AND LOAD ON BEARING
(From paper by Needs; pressure coefficient given on curves in per cent per 100 atm; all lubricants of same atmospheric viscosity.)

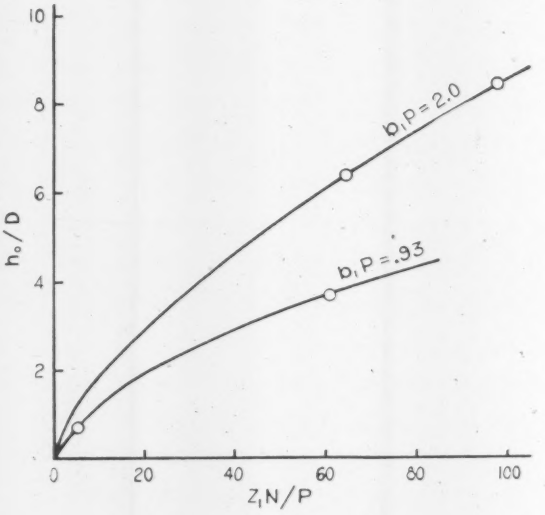


FIG. 2 FILM THICKNESS CALCULATED FOR GEAR LUBRICATION
(From Gatcombe's investigation; P denotes F/D where F is tooth load in pounds per inch of face width, D the pitch diameter, and Z_1 the viscosity at 1 atm.)

[1] Research Associate in Mechanical Engineering, Massachusetts Institute of Technology, Cambridge, Mass. Fellow A.S.M.E.

[2] Chief Engineer, Southern Acid & Sulphur Company, Inc., St. Louis, Mo.

[3] Numbers in parentheses refer to the Bibliography at the end of the paper.

Contributed by the Special Research Committee on Lubrication and presented at the Annual Meeting, New York, N. Y., Nov. 26–29, 1945, of THE AMERICAN SOCIETY OF MECHANICAL ENGINEERS.

7.2 microinches in a 2-in. pinion, and for the petroleum oil 6 × 2 or 12 microinches.

The foregoing results are based on Gatcombe's investigation, assuming rigid gear teeth and a uniform temperature throughout the film (48). A brief discussion of dimensionless variables influencing thin-film lubrication when the surfaces are deformable, and the temperature is nonuniform, will be found in reference (22). The fact that the theory of high-pressure effects in lubricating films has been so well confirmed by bearing experiments creates a lively interest in conducting similar tests on gear lubrication, as proposed by Dr. Gatcombe in the reference cited.

VISCOSITY EXPERIMENTS

Professor Barus of Brown University was a pioneer in high-pressure technique. He published a viscosity-pressure-temperature diagram for marine glue as early as 1893 (1). Other investigations are described by Professor Bridgman of Harvard (18). No measurements on the change in viscosity of lubricating oils under pressure have been found prior to the work of the A.S.M.E. Committee.

The first such measurements were made in a boiler gage glass. After demonstrating the effect, a steel tube was constructed. This work was done in Professor Bridgman's laboratory using the ball-and-slanted-tube, or "rolling-ball" viscometer invented by Dr. Flowers (3). The results of a comparison of petroleum oil and lard oil at room temperature were published in 1916 (4), showing that the petroleum oil had the greater pressure coefficient.

Although the American investigation was interrupted by the war, the need for such experiments gained recognition in England. An investigation was accordingly begun at the National Physical Laboratory, the results of which were published by Hyde in 1920 (6). The method utilized capillary tubes. Four fatty and five petroleum oils were tested at 40 C (104 F). Hyde found the pressure coefficients greater for petroleum than for fatty oils.

The American investigation was resumed by Hersey and Shore at the Massachusetts Institute of Technology. Two fatty and three petroleum oils were tested at several temperatures not exceeding 135 C (275 F). A final report was presented at the Annual meeting of the A.S.M.E. in 1927 (14). This paper should be consulted not only for the complete data on five oils, but also for the description of the pump and intensifier, and for safety precautions. Recommendations for future research were included, some of which have since been carried out. An interesting feature was the observation of "apparent solidification," a plastic condition occurring in certain oils when the pressure is sufficiently increased.[4] The curves for oil 42, shown in Figs. 3 and 4, were obtained from this investigation. It was supplemented by tests on a low-viscosity petroleum oil (16), using the same steel tube with a larger-diameter ball.

A viscometer of the falling-body type was constructed by Professor Bridgman for determining the viscosities of about forty-five liquids, including oleic acid, kerosene, glycerin, and water (10). This equipment was kindly placed at the disposal of the A.S.M.E. Committee and used by Dr. Kleinschmidt (15) in testing four fatty, two petroleum, and two compounded oils at temperatures not exceeding 80 C (176 F). Kleinschmidt's curves for castor oil, actually carried to much higher pressures, are shown in part in Figs. 3 and 4.

Kiesskalt's investigation at Karlsruhe was published in 1927 (13). His viscometer was also of the falling-body type. Three fatty, seven petroleum, one compounded, and one coal-tar oil were tested at temperatures up to 80 C (176 F).

Suge experimented at Tokyo with a falling-sphere viscometer. His observations were published in 1932 and 1933 (21, 23). Six fatty, eighteen petroleum, and five compounded oils were tested, some of them at temperatures as low as 1 deg C (about 34 F) and as high as 156 C (about 313 F).

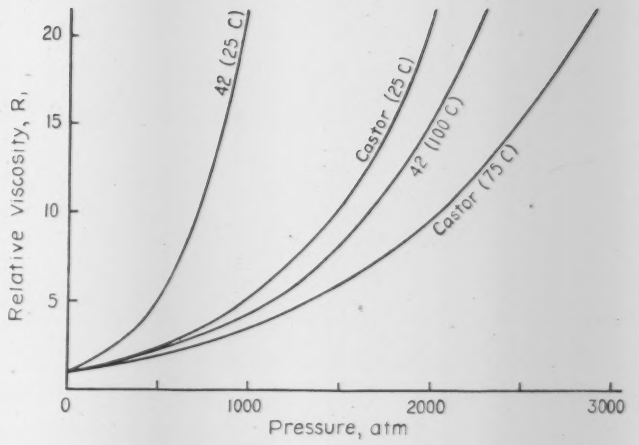


FIG. 3 RELATIVE VISCOSITY WITH INCREASING PRESSURE

(Petroleum oil 42 from investigation A_1 and castor from A_2 at two temperatures; R_1 denotes ratio of viscosity at any pressure to that at 1 atm.)

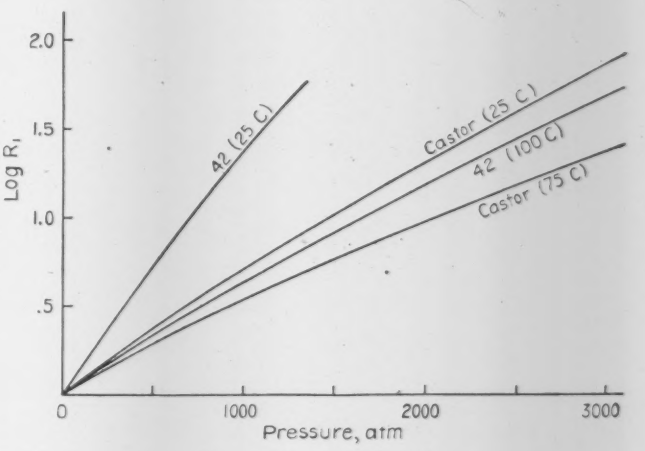


FIG. 4 LOGARITHMIC ISOTHERMS

(Relative viscosity logarithms corresponding to previous figure.)

A third American investigation was conducted by Sage, Lacey, and associates at the California Institute of Technology in connection with their study of hydrocarbons containing gases in solution. Two petroleum oils of lubricating grade were tested at temperatures up to 220 F (about 106 C) in a rolling-ball viscometer. The results were reported in 1935 and 1937 (27, 36).

A fourth American investigation was conducted by Professor Dow and associates at The Pennsylvania State College. Dow had completed his research on the viscosities of mixtures of pure liquids in Professor Bridgman's laboratory (26), together with a study of pressure-volume-temperature relations in lubricating oils for the Special Research Committee (25). The results thus far published, beginning in 1937, include data on twenty petroleum oils and a number of other liquids at temperatures up to 210 F (about 99 C). The oils were carefully selected with respect to their composition and refining history (31, 32, 38, 39, 43). A rolling-ball viscometer was used throughout the investigation and checked against a rotation instrument in some of the high-pressure tests (39).

Bolarovich reported experiments on five petroleum oils and on glycerin-sugar solutions at temperatures not above 60 C (140 F). He employed a falling body with pulley and counterpoise (40); but since nitrogen was used for transmitting pressure and must have entered into solution, the measured viscosities are somewhat low. This, however, the author points

[4] See reference (2), p. 208.

out, would approximate the conditions met in lubricating air compressors.

A fifth American investigation was reported by Gunst of the Gulf Research & Development Company in 1941 (44). Four petroleum oils were tested to 180 F (about 82 C) with a rolling-ball viscometer.

The sixth American investigation, that of Norton, Knott, and Muenger published in 1941 (45), had for its object the measurement of the consistency of oils solidified under pressure. This study is closely related to the committee's experiments on the flow of greases under high pressure (20). The long-capillary apparatus used by Hersey and Snyder was therefore placed at the disposal of Professor Norton and modified as his work progressed. Four fatty oils and one petroleum oil were tested at temperatures from —5 C (23 F) to 20 C (68 F), low temperatures being chosen at first to accentuate the plastic condition under moderate pressures. Although this investigation was interrupted by Professor Norton's death, the report is accompanied by a fruitful discussion containing valuable suggestions for the future.

The pressure ranges and other particulars of the ten investigations are summarized in Table 1, where the American investi-

TABLE 1 SCOPE OF INVESTIGATIONS

Investigation	First publication	Lubricants tested: Fatty	Petroleum	Total	Highest temp, deg F	Pressure range[a]: Atm	Psi
A_1	1916[b]	2	4	6	275	4100	58000
A_2	1925[c,b]	5	3	12[d]	176	12000[e]	170000[e]
A_3	1935[b]	..	2	2	220	250	4000
A_4	1937[b]	..	20	20	210	4100	58000
A_5	1941	..	4	4	180	350	5000
A_6	1941[f]	4	1	5[f]	68	3500	50000
B	1920	4	5	9	104	1300	18000
G	1927	3	7	12[d]	176	800	11000
J	1932[b]	6	18	29[d]	313	2000	28000
R	1940	..	5	7	140	1000	14000

[a] Maximum for any isotherm; mean range less. Values rounded to a thousand pounds per square inch.
[b] More fully reported in the later references.
[c] Bridgman, Proceedings, National Academy of Sciences.
[d] Includes compounded oils and other lubricants.
[e] Glycerin only; maximum for castor oil 9500 atm, lard 7200, others less.
[f] Not including grease tests of reference (20).

gations are identified by the symbols A_1 to A_6, and the British, German, Japanese, and Russian by B, G, J, and R, respectively.

CONDENSED TECHNICAL DATA

Pressure coefficients b_1 and viscosities at atmospheric pressure Z_1 are given in Tables 2 and 3 for fatty and petroleum oils, respectively. In general the pressure coefficient b at any pressure p is defined as the rate of change of the viscosity Z with respect to p at constant temperature, divided by Z. The subscript 1 is attached to indicate the value at atmospheric pressure. Similarly, the temperature coefficient a at any temperature t is defined as the rate of change of Z with respect to t at constant pressure, divided by Z.

Actually, the coefficients were computed from the initial slopes of logarithmic isotherms obtained by plotting smooth curves from the published data. Consider, for example, the top curve in Fig. 4. Draw a tangent line at the origin. Let the slope of this line, which is the constant ratio of log R_1 to p, be denoted by δ. It follows that $b_1 = 2.3\,\delta$. For the curve in question, reading off the height of the tangent line where it crosses the ordinate at $p = 1000$ atm makes the slope δ equal to 1.48 divided by 1000. Therefore, $b_1 = 2.3 \times 0.00148 = 0.0034$ atm^{-1} or 0.34 per cent per atm or 34 per cent per 100 atm.

Conversely, a knowledge of b_1 makes possible a rough prediction of the relative viscosity R_1 representing Z/Z_1 at any desired pressure. Given $b_1 = 0.34$ per cent per atm and assuming a straight logarithmic graph, we should expect log R_1 to equal 3.4 divided by 2.3, or 1.48 at 1000 atm. The true value of log R_1 is 8 per cent less. Hence it is important to recognize the curvature of the logarithmic graph when making calculations for pressures any greater than a few hundred atmospheres. Curvature data have been recorded for all the oils in the literature.

TABLE 2 DATA ON FATTY OILS

Oil	Z_1 (100 F), centipoises	b_1 (100 F), per cent per atm	Investigation
Rapeseed[a]	590	0.18	A_2
Castor[b]	245	0.15	A_1, A_2, B, J
Neatsfoot	40	0.11	G
Rapeseed	40	0.13	B, J
Whale	40	0.10	J
Peanut	38	0.115	G
Trotter	38	0.18	B
Camellia[c]	37	0.115	J
Lard[d]	32	0.17	A_1, A_2
Sperm[e]	31	0.16	A_2
Linseed	26	0.10	G
Hemp[c]	24	0.115	J
Horse[c]	24	0.115	J
Sperm[f]	17.5	0.145	B
Oleic acid	16.5	0.175	A_2

[a] Apparently oxidized or "blown;" see below.
[b] Mean of four samples from 240 to 250 centipoises, with b_1 progressing from 0.13 to 0.17.
[c] Extrapolated from 18 C (about 64 F).
[d] Mean of 28- and 36-centipoise samples, b_1 progressing from 0.16 to 0.175.
[e] Mean of two samples, "NPL" and "Unrefined."
[f] NPL sample only.

TABLE 3 DATA ON PETROLEUM OILS

Group no.	100 F: Z_1 centipoises	100 F: b_1 per cent per atm	210 F: Z_1 centipoises	210 F: b_1 per cent per atm	Investigation
1	1640	0.40	32	0.25	A_4
2	453	0.38	16	0.21	A_4
3	225	0.22	15	0.14	J
4	114	0.32	8.0	0.19	A_4
5	57	0.28	6.0	0.195	A_5
6	28	0.24	3.6	0.165	A_3
7	14	0.20	3.0	0.165	A_4
8	1.6	0.10	0.65	0.045	A_2

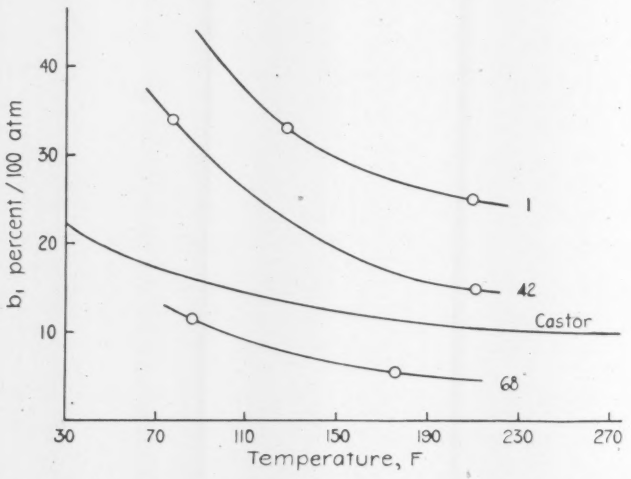


FIG. 5 PRESSURE COEFFICIENTS PLOTTED AGAINST TEMPERATURE (Petroleum oils 1, 42, and 68 represent high, medium, and low viscosity; castor-oil curve typical of fatty oils.)

Tables 2 and 3 offer a skeletonized view of the extensive data available. The b_1 values have been read from smooth curves of the kind shown in Fig. 5. Fatty oils are identified by name and values tabulated at 100 F. Table 2 is based in part on the data given in an earlier report (34). Petroleum oils are numbered in descending order of viscosity at 100 F. They were divided into a geometrical progression of eight vis-

cosity groups. A representative oil was taken from the middle of each group, and the values recorded in Table 3 at 100 and 210 F. A comparison of the b_1 values in Table 3, ranging from 0.38 down to 0.20 per cent per atm in Groups 2 to 7, with the b_1 values for the corresponding viscosities in Table 2 ranging from 0.18 to 0.10 per cent per atm, shows that the effect of pressure is about twice as great on petroleum oils as on fatty oils. This relationship is confirmed by Fig. 6.

Compounded oils are characterized by properties intermediate between those of the base oil and the fatty component.

Solidification phenomena have been discussed previously (2, 7, 10, 14, 15, 19, 23, 24, 37, 46). Henry Shore discovered an approximately linear relation between solidifying pressures and temperatures.[5] Poulter suggested solidification of the moisture content and other ingredients of lubricating oils as a possible cause of abrasion (37). Dow found no discontinuity of volume when apparent solidification occurred (46). Norton, Knott, and Muenger made the first measurements of yield point and mobility in oils solidified under pressure (45). Their curves for shearing stress against rate of shear can be replotted to show the decrease in viscosity accompanying increasing rates of shear, since viscosity is defined as the ratio of shearing stress to the rate of shear. Both in capillary flow and lubricating films, the rate of shear may be taken equal to the velocity gradient.

Non-Newtonian characteristics, such as plasticity and time effects, are conspicuous in solidified oils at low rates of shear. The question has long been considered as to whether any deviation from the usual hydrodynamic assumptions may be expected under practical operating conditions, particularly at high rates of shear, see, for example, references (5) and (47).

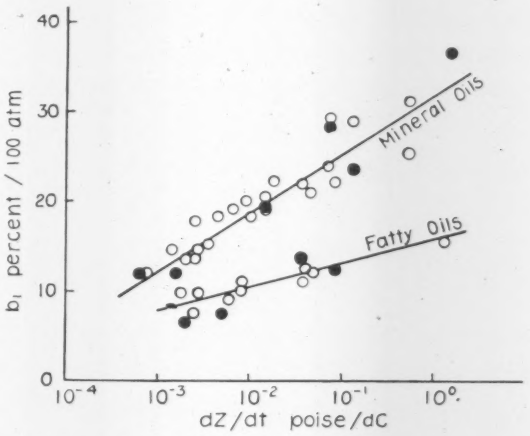


FIG. 6 KIESSKALT'S CORRELATION OF PRESSURE AND TEMPERATURE EFFECTS

(Open circles from investigation G, solid from A_1; pressure coefficient plotted against the viscosity-temperature slope in poises per deg C.)

Needs' experiments are reassuring on this point (35) and offer a possible technique for further investigation.

CONCLUSION

This paper describes the first part of a study aiming to coordinate the published data on viscosity of lubricants under high pressure. The objectives of the entire study are, first, to survey what has been accomplished, indicating some of the directions in which future research may be required; and, second, to put the data already available into a more convenient form for practical use.

The co-ordination project has been completed in so far as can be done by plotting, tabulating, and comparing the original published data. Differences in units and methods of representation have been eliminated. It is evident that further experimentation is needed in several directions, particularly (*a*) in increasing the pressure range, (*b*) widening the temperature limits, and (*c*) taking into account the rate of shear or its equivalent, the shear stress, as an independent variable.

In the meantime useful applications can be made by graphical and mathematical methods. A study is now in progress of the various correlation attempts that have been described. One of the most rational, though probably oversimplified, is that of Kiesskalt (17), illustrated in Fig. 6. Such correlations aim to predict the effects of pressure variation from a knowledge of the properties of an oil at atmospheric pressure.

Finally there should be a more systematic development of curves and equations for representing past and future data on viscosity-pressure-temperature relations. At the moment, it is difficult to compare the results of high-pressure tests made on one oil at 25, 40, and 75 C, the earlier standard temperatures, with those on another at 100, 130, and 210 F. The contributions of Barus, Suge, Cragoe, and others (1, 13, 23, 24) provide a good running start. The problem of the viscosity relations for lubricants is analogous to the classical steam-tables investigation conducted by the Society not long ago.

ACKNOWLEDGMENT

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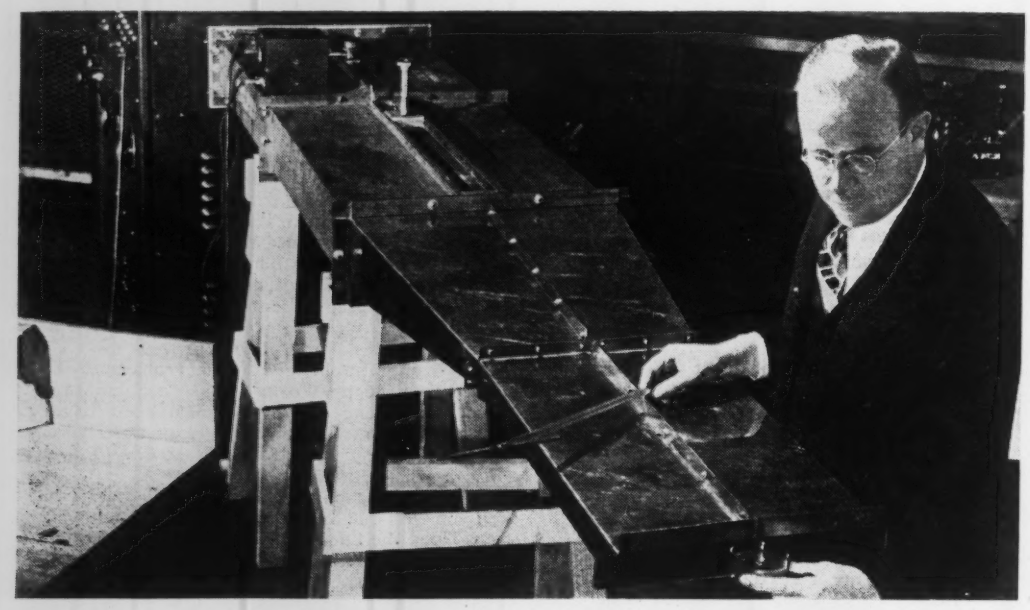

ELECTRONIC "BLOWTORCH" HURLS RADAR BEAM TO HEAT PRODUCTS

(An experimental model of an electronic "blowtorch" that projects high-frequency radio waves on materials is demonstrated at the Westinghouse Research Laboratories by Dr. J. A. Hutcheson, associate director. The liquid plastic in the dish held by Dr. Hutcheson can be solidified in three minutes. After further development, this new means of hurling invisible waves will permit projection of high-frequency heat on an object wherever it may be, as opposed to present industrial dielectric heating methods in which objects must be placed between metal plates or electrodes, and will assure uniform heating of irregular shapes. Eventually, greater power at higher frequencies may allow "squirting" of the beam from a nozzle no bigger around than a flashlight.)

Discussion of HYDRAULIC MATERIALS TRANSPORTATION

By F. B. ALLEN[1]

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THE cost of mining is largely a materials-transportation expense. This is particularly so in open-pit mining, as generally the ore lies from 50 to 300 ft beneath the surface, and therefore from 2 to 10 tons or more of useless overburden must be moved for each ton of ore obtained. Even this "ore" is from 40 to 60 per cent refuse and so in fact only from 5, or less, up to 20 per cent of the material transported is of value.

There are various practical methods of transporting this overburden and ore:

1 It may be hauled by truck or rail, or both.
2 It may be moved by endless belts.
3 It may be transported by water or air in a pipe line.
4 Any combination of 1, 2, or 3 may be applied.

ADVANTAGES OF HYDRAULIC SYSTEM

All four schemes unquestionably have their best applications. It is the purpose here to consider only the advantages and disadvantages of scheme 3 where water is used. The general advantages of this scheme, when properly applied, are as follows:

1 It is relatively inexpensive in first cost.
2 It lends itself to either vertical or horizontal transportation.
3 It allows of vertical lifts or lifts at any slope.
4 It is extremely applicable in long-distance horizontal transportation.
5 Because of reason 4, where ore must be beneficiated, the washing plant may be located centrally of several pits.
6 The scheme allows of simple disposition of overburden at a distance. Thus "lean" ores, which may become valuable as reserves are depleted, need not be covered by overburden disposal.
7 In pumping ore having matrix mechanically attached, the turbulence produced by pumping undoubtedly helps separate the two and thus reduces the work of the "logs" in the washing plant.
8 There are no moving parts in such a conveying system other than the pump impellers.
9 The solids are totally enclosed from the time they enter the system until their delivery. No dust, slime, or slop occurs during transportation.
10 There are no roads or roadbeds to build, or tracks to lay. The right of way required is narrow, needs almost no grading or other preparation.
11 Elaborate repair shops, parts, tires, oil and fuel storage are not required as with trucking or rail haulage.
12 The power cost is low—about $1^1/_2$ cents per ton-mile of solids horizontally transported.
13 The maintenance cost is likewise low; less than 25 cents per ton-mile will maintain the pipe line and pumps.

A TYPICAL HYDRAULIC OPERATION

To give an idea of the possibilities, the following example will demonstrate typical methods as they might be applied to an overburden moving operation:

It is proposed to move 700 yd per hr of overburden, depositing it 4000 to 6000 ft from the excavation. There is a total 3,000,000 cu yd to move, and it is intended to accomplish this in a period of 7 months, or 200 working days of 22 hr each, i.e., 4400 hr. Actually, if 700 yd are moved per hr, in 4400 hr a total of 3,080,000 cu yd could be moved.

It is proposed to dig this material with a 12-yd dragline, the average depth of excavation being 40 ft below average grade level of the property. The dragline is to unload into a portable preparation plant. The dragline and preparation plant are to set a grade, moving together as required.

The preparation plant is to consist of a 40-cu-yd hopper into which the dragline casts. The material then drops onto an apron conveyer which feeds at the same rate of 700 yd per hr onto a double-roll grizzly. This will pass all material of —6 in., but reject into a crusher all oversize. The crusher will reduce to —6 in. all material which enters it. The solids passing through the crusher plus those —6 in. which by-passed the crusher will drop into a large sump wherein a constant water level is maintained. This constant water level is maintained by means of a 12-in. pilot-relay-controlled valve connected to a water line wherein there is always available from 3500 to 5500 gpm of water at a pressure of 30 to 40 psi.

The suction of a materials-handling centrifugal pump is connected at the bottom of the sump. This pump, when operated at the proper speed, will discharge the mixture of water and solids to point of final disposal. The water is allowed to drain slowly to a low spot adjacent and is then recirculated to the pump sump.

In the case here considered, on the assumption of 3000 lb of solids per cu yd, there must be 2,100,000 lb of solids to be handled per hr. Now, assuming these solids to have a specific gravity of 2.7, this means they occupy a volume the equivalent of $\frac{2{,}100{,}000}{8.3 \times 2.7} = 94{,}000$ gal, that is, the volume of solids per minute equals $\frac{94{,}000}{60}$ or 1570 gpm. For the purpose of this paper, we are assuming that the overburden will be handled when in a solution having a specific gravity of 1.46. The water required for this solution is therefore 4240 gpm. Thus the total mixture to be pumped would be 5810 gpm. This would give a velocity in a 12-in-ID line equal to $16^1/_2$ fps, which practice shows to be adequate to maintain solids of this size and gravity in "solution," that is, active turbulence so that the solids will not settle to the bottom of the pipe line.

Experience indicates that under such conditions there will be a friction loss in the pipe line of about 8.75 ft per 100. Assuming that the discharge point is 30 ft above the grade, this means that 2 centrifugal pumps operating in series must be used to generate a total head of about 400 ft when discharging 5800 gpm of 50 per cent by weight concentrated solution of solids and water. The centrifugals under this condition will consume about 500 hp each. The primary centrifugal should be direct-connected to a wound-rotor motor with speed variations through a drum controller of 40 per cent. The secondary

[1] Mr. Allen died on April 8, 1945.—EDITOR.

Presented at a Meeting of the Anthracite - Lehigh Valley Sections, Hamburg, Pa., March 23, 1945, of THE AMERICAN SOCIETY OF MECHANICAL ENGINEERS.

pump should be direct-connected to a constant-speed motor. The second pump should be located preferably some 200 to 500 ft from the primary pump, in order that the solution may always enter the second pump under a decided pressure above atmospheric.

To obtain average hourly cost of operation of this setup, we would estimate as follows:

Labor, dragline, 2 men	$ 4.00
Preparation plant, 2 men	4.00
Pipe line, 4 men either at preparation plant or at refuse pile, as required	4.00
One general repair man	2.00
Hourly total labor	$14.00
Power, dragline	500 hp
Two pumps	1000 hp
Auxiliary power	100 hp
Repumping water	400 hp
Preparation plant	300 hp
Total power	2300 hp
Or approximately 1800 kw equal to	$27.00 per hr
Maintenance, pumps per hour	$ 2.00
Pipe line per hour	0.25
Preparation plant per hour	2.00
Dragline per hour	2.00
Total maintenance	$ 6.25
Total cost 1 hr	$47.25

As there are 700 cu yd handled per hr, the total cost of transporting the material (interest and depreciation omitted) is $\frac{\$47.25}{700} = 6.75$ cents per cu yd. Note that this includes cost of digging and transporting to point of final disposal.

As to initial cost, we estimate as follows:

12-yd dragline	$200,000
Preparation plant	60,000
Pumps and motors	30,000
Pipe line laid	12,000
Miscellaneous equipment	10,000
	$312,000

If this equipment is depreciated on the basis of 20 per cent that is, 15,000,000 yd, the cost per year would be $62,000, and per hour $\frac{62,000}{4400} = \$14.00$, or 2 cents per yd for depreciation; interest at 4 per cent would amount to $12,480 annually, $2.80 per hr, or 4 cents per yd. Total cost including interest at 4 per cent, depreciation in 5 years, all labor, power, and repairs, $6.75 + 2 + .4 = 9.15$ cents per cu yd; $\frac{9.15}{1.5} = 6.1$ cents per short ton, or 6.7 cents per long ton.

PROPER SELECTION AND INSTALLATION OF EQUIPMENT VITAL

To avoid operating difficulties, the following should be observed:

1 A good pump must be used.

2 A good pump cannot overcome faulty installation or operation.

Under item 1 consider the following:

(*a*) Use material in the impeller, side plates, and volute that will best withstand the abrasion to be met.

As a rule, where pulps, slimes, and sands are to be pumped, rubber is by far the best material, but large tramp pieces must be screened out.

On the other hand, where material larger than No. 8 mesh is to be pumped, alloy irons will prove most suitable.

(*b*) The bearings and shaft must be rugged, for incalculable stresses are often set up.

(*c*) The space between the rotating impeller and stationary suction side plate must be sealed with a clear nonabrasive liquid. Otherwise the abrasive solution pumped will wear large clearances, and a decided proportion of the pumped solution will leak back to suction and have to be repumped. This will result in loss of efficiency and capacity in short order. Likewise, the maintenance of parts will rapidly increase.

Most pumps are called upon to pump varying quantities of solution due to surges in the feed. As a result, it has been common practice to install a pump that will handle the maximum surge. Hence during normal operation, the feedbox is sucked dry. The pumps then work with no solution until suction is again picked up. The velocity in the pipe line during this period is zero, the material drops out of solution and must be started into motion again after the pump suction is re-established. As a result, the surges at the pipe-line discharge are further exaggerated, while power and maintenance costs of the pump are increased.

This difficulty may automatically be obviated in the following ways:

1 Make the sump as deep and of as great a volume as feasible. The deeper the better, for as the solution level gets higher in the sump, the pump will handle more as it has a lower head to work against.

2 Fix a minimum solution level in the sump. If the solution goes below this level arrange by float control to introduce auxiliary water into the sump.

3 If it is undesirable to introduce auxiliary water, the float can operate a pilot that in turn can either mechanically or electrically slow the speed of the pump, thus reducing capacity.

Design a sump having one straight side and the other three sides sloped at 60 deg to the horizontal to form a flat bottom about 18 in. long × 12 in. wide. Put the suction of the pump at the bottom of the sump. Run the pipe as directly to the pump suction as possible, using a type of coupling which provides for easy assembly or disassembly of this suction line.

4 Where valves are used in the solids-solution lines, use "flap" type with the valve opening in the direction of flow of material.

5 Carefully determine the velocities necessary to keep materials in suspension during design. Then choose the correct size of pipe line to attain this result, based on the amount of solution to be handled. Do not have two sizes of pipe in the same run.

6 Make all bends of long radius, that is, 6 times the pipeline diameter.

7 Be sure that sealing water on both the suction side and the stuffing-box side is free of serious abrasives.

8 When possible, make pipe lines run substantially horizontally or vertically. If they are rising, never make them rise at a rate of less than 45 deg from the horizontal.

9 It is wise to keep on hand spare pump parts as follows: Volute, impeller, side-plate liners, suction-seal parts, packing, shaft, and a complete set of bearings.

10 Check pump operation regularly, i.e., pressure (suction and discharge); test seals to be certain they are functioning properly. Take temperature of bearings; regularly drain and replace bearing oil, etc. Any sudden variation in conditions in general means something is wrong.

11 When designing a system, always figure on pumping at as high a concentration of solids as is feasible. It must be well understood that it is solids which are to be moved—not water. It takes power to move either; hence the less percentage of water and the greater of solids, the less power per ton of materials will be required under a given condition.

Good design, good equipment, and good operation pay the best dividends.

FIG. 1 EXTERIOR VIEW OF WIND TUNNEL LABORATORY

SUPERSONIC WIND TUNNEL LABORATORY

Aberdeen Proving Ground

By MAJOR GENERAL G. M. BARNES[1]

OFFICE CHIEF OF ORDNANCE, WASHINGTON, D. C.

IN this era of speed, wind tunnels have become so common that all engineers, and many laymen, know something about them and their use in obtaining data on airfoils, parts, and equipment of airplanes. Not so generally realized, however, is the fact that the study of air flow did not start with the airplane but, instead, in the science of ballistics, an important phase of which is research into the behavior of a projectile in flight.

As long ago as 1889, the idea for the use of air at supersonic velocities, i.e., above the 1150-fps speed of sound, for study of certain physical phenomena evident when a projectile is mounted within the stream of air, was advanced by the Austrian physicist and mechanic, Ernst Mach, professor of physics in Prague. It is not clear what, if any, application was then made of this suggestion in the study of projectiles. Mach's research, however, stimulated further study in several countries.

Today the most advanced supersonic wind-tunnel laboratory in the world is in operation at the Army Ordnance Department's Ballistic Research Laboratory at Aberdeen Proving Ground, Maryland, Fig. 1. One tunnel in that laboratory, that for testing bombs, is designed to produce air speeds of 1.7 times the velocity of sound, or about 1300 mph, while the other, the ballistic tunnel, will provide air speeds of 4.4 times the velocity of sound, or more than 3000 mph.

Despite the fact that man has been hurling missiles at his enemies for centuries and, in these later decades, has speeded up much of his equipment, especially in the field of transportation, there are still many applications of high velocities whose fundamental nature is little understood. This is particularly true in respect to the newer high-velocity shells, bombs of free-fall and radio-guided varieties, ordinary rockets, and the supersonic rockets introduced by the Germans. World War II gave birth to some of these and saw redevelopment and improvements made to others.

WIND TUNNEL AIDS ORDNANCE DESIGNERS

For the study of the flight of such military missiles, there is a well-developed and precise science known as "exterior ballistics." The adjective denotes flight of the missile in air after it has left the gun, airplane, or other launcher. Hence it is obvious that, in order to study the flight characteristics of a new projectile or bomb, it has been necessary in the past to make the missile. This usually entails a costly time-consuming process of manufacturing a considerable number, testing them, and then making more of them to incorporate any changes that may have been shown to be necessary by the development test. Sometimes the sequence of design, manufacture, and test may have to be repeated several times before a particular design of shell or bomb is declared most effective for a particular purpose. Seldom is there a short cut, and months of time, precious during a war, are consumed in "cut-and-try" methods.

Suppose the new materiel is an artillery shell. After the de-

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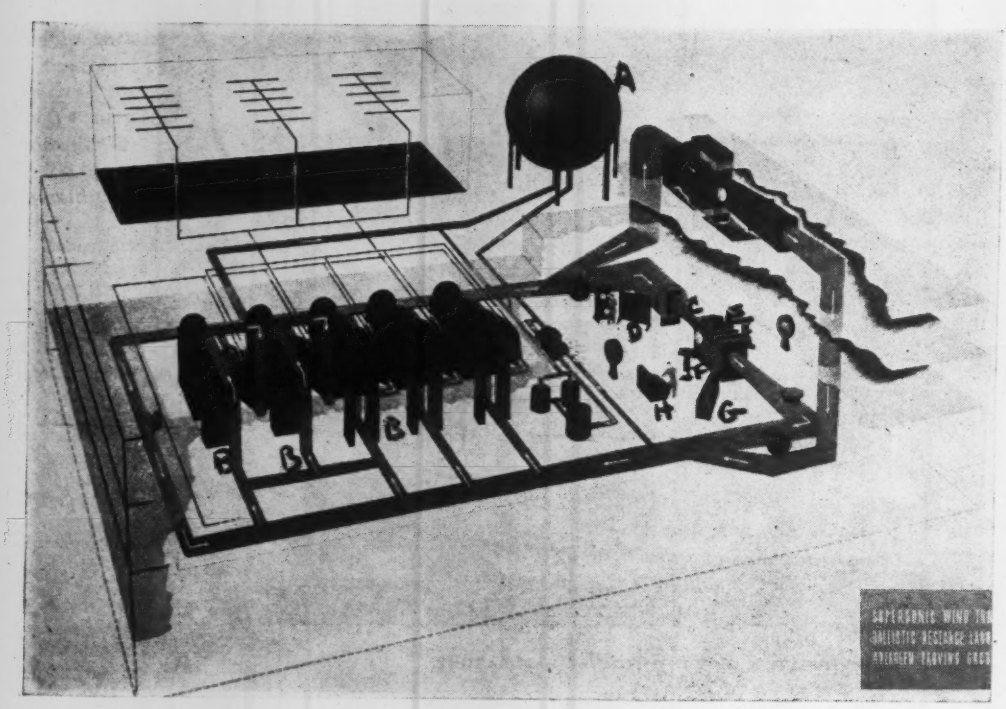

FIG. 2 SCHEMATIC ARRANGEMENT

(*A*—Air reservoir; *B*—motors and compressors; *C*—nozzle; *D*—manometer board; *E*—test section; *F*—schlieren camera; *G*—instrument board; *H*—control desk.)

sign has been worked out by the engineers, a contract is made with a manufacturer who then must retool a portion of his plant to do the job. He makes a number of shells, say, a hundred, and ships them to Aberdeen Proving Ground. There they are test-fired from a suitable gun, and a careful record made of their flight characteristics. To gather data on these, shells are fired through or past various complex instruments such as solenoid coils or Aberdeen velocity screens, mounted singly and in multiple. Long and tedious mathematical operations are necessary to obtain the definitive data required.

Gun-fired projectiles, and to some extent rockets, can be tested in this manner, but bombs call for a different technique. There is no way a crew outside and independent of the "flying artillery" that fires the bomb may set up instruments to study it at close range. A bomb will go through the same procedure of design and manufacture as the shell. Then it must be shipped to a large bomb-test area. There it will be taken aloft to a high altitude and dropped toward a given target, while cameras on the ground record its fall and provide practically all the data obtainable. Specialized precision instruments must be used for all data, because ordinary airplane instruments are not suited for these purposes. The many variable factors involved in bombing make it impossible to obtain as precise information about bombs as is the case with projectiles.

The inevitable trend of war toward wide use of such finned projectiles as the V-2 type introduced by the Germans presents an even greater problem to ordnance engineers and designers. If these are to be accurately aimed for most effective use, their air-flow characteristics must be unquestionably exact and fully known.

Science, handmaiden of war since long before the engines of Archimedes stood off the enemy before ancient Syracuse for three years, comes to the aid of ordnance designers in the form of the wind tunnel. This device enables the engineer to duplicate the phenomena of the flight of a missile under controlled conditions at one spot, by flowing the air past a stationary model of the projectile or bomb. Rather than shooting a large number of rounds from small arms or artillery weapons and making a fraction-of-a-second record of each, or dropping a large number of bombs and having only a series of photographs as working data, the ordnance engineer with a wind tunnel can make one model of each missile and study its flight characteristics continuously and for as long a time as he desires. Not only can he take photographs of it under varying conditions which he, himself, controls, but also he can make visual examinations at will of the model under test.

THE TUNNEL AT ABERDEEN

The Supersonic Wind Tunnel Laboratory at Aberdeen is part of the Ballistic Research Laboratory at the Ordnance Research and Development Center, Aberdeen Proving Ground, Maryland. Within a separate three-story brick and concrete building are a supersonic bomb tunnel, which has been in operation for some time, and part of the structure of a supersonic ballistic tunnel, which is to be completed shortly.

In the former tunnel, for taking readings on the flight of bombs, fixed nozzles are used to produce high-velocity air flow. One nozzle now available is subsonic, giving all velocities up to a usable velocity of 0.9 of the speed of sound or, as we say technically, up to a Mach number of 0.9 (written Ma 0.9), the Austrian physicist Mach's name having been adopted for this purpose. A second available nozzle is rated at Ma 1.7. A third is now being manufactured for Ma 1.3.

The test section of the bomb tunnel, i.e., that portion directly downstream from the nozzle, is 15 in. wide × 20 in. high and can take models about 2 in. in diameter. The model-suspension system of this tunnel is of the three-component type, i.e., it can measure the drag, the lift, and the overturning moment of the model bomb. An adjustment outside the tunnel is used to turn the model through an angle-of-attack range of —10 deg to +10 deg.

The second is the ballistic tunnel. It will not be handicapped in its test range by dependence upon the number and rating of nozzles available; it will have a flexible nozzle that will permit rapid adjustment of ratings from a very low Mach number to about Ma 0.9, and from about Ma 1.1 to Ma 4.4.

THE TRANSSONIC BLIND SPOT

The gap between Ma 0.9 and Ma 1.1 is untouchable at present by the wind-tunnel technique and will continue to be unless and until science discovers some new principle of testing. It is the so-called transsonic, or "blind-spot" region. To understand why it is present, it is necessary to consider the basic principles of the action of the shock waves of air which flow off the nose of the model being tested, as waves, in water, flow off the bow of a moving boat. Shock waves also flow off a projectile in flight, but may be noted only momentarily on a spark or schlieren photograph as the projectile passes, while they may be studied continuously around a similar projectile or model in the wind tunnel. In both cases, the pattern of shock waves around a given test model, their angles, density, and other characteristics provide the scientists with data from which can be deduced mathematically many of the desired

ballistic characteristics. Others are obtained by the balance system which will be discussed in more detail later.

Shock waves from a model, suspended in a low-velocity (subsonic) stream of air, assume an angle upstream and outward toward the walls of the test section. From the walls they are reflected inward downstream, the angles of incidence and reflection being almost equal. As the velocity of the air increases, the point of impact on the walls moves backward toward the model, the angles of incidence and reflection increasing. As air velocity approaches the speed of sound, i.e., Ma 1, the reflected shock wave, having moved backward far enough, hits the model itself and thus nullifies the test. This happens at about Ma 0.9 for the smallest practical models and earlier for large ones. If the air velocity is increased to Ma 1, the exact speed of sound, the shock wave is reflected back upon itself, in a plane normal to the axis of the model.

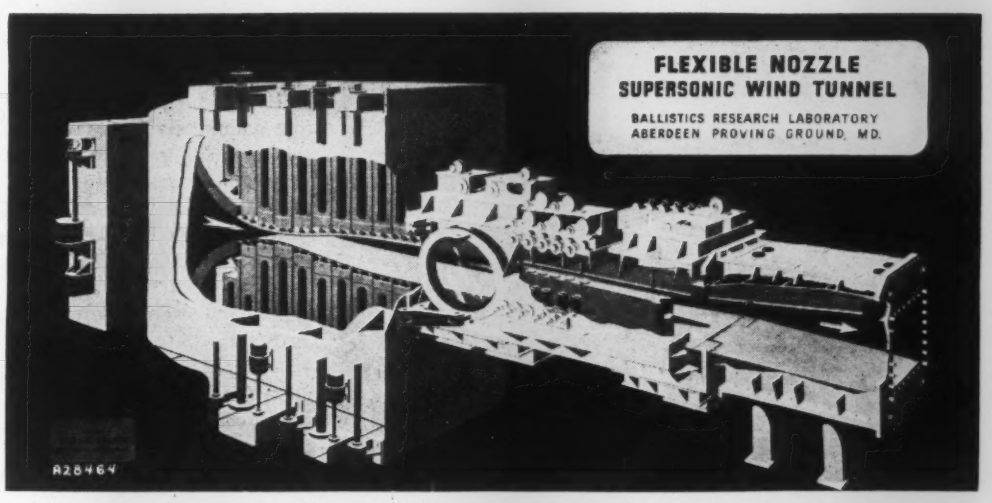

FIG. 3 FLEXIBLE NOZZLE FOR BALLISTIC TUNNEL

As the velocity of the air is increased into the supersonic range, the shock waves begin receding downstream; and at about Ma 1.1 pass the point at which the reflected wave hits a model of convenient size. Further increases of air velocity free the model of any reflected-wave interference, and tests may be made accurately.

It may seem that, in order to make tests at Ma 1 in the transsonic region and still prevent the reflected waves from hitting the model, it would be necessary to have either a test section of infinite diameter or a model of zero size.

The ballistic tunnel will have another advantage over the bomb tunnel besides its flexible nozzle. While the balance system of the latter is of the three-component type, that of the ballistic tunnel is of six-component design. It will measure the lift, drag, and overturning moment of a model and, in addition, the side force and two components of the moment of the side force. As in the bomb tunnel, the strut supporting the model from the rear and the balance system both are shielded from the air stream by a windshield.

SPINNING MODELS BEING DEVELOPED

Testing is ordinarily conducted with stationary models, but a tiny motor is being developed to be enclosed in the models to spin them at 60,000 to 80,000 rpm. This motor, together with the six-component balance system, will permit testing of spinning projectiles. Studies of this sort will be especially important in the case of such new and partially unpredictable materiel as high-velocity artillery shell and spin-stabilized rockets and should provide the data necessary to determine their design for most efficient flight.

SCHLIEREN APPARATUS

Schematically, both wind tunnels are of the continuously operating closed-circuit type, that is, high-pressure dry air, moving from the compressors, passes through the nozzle, and thence past the model in the test section into the diffuser, returning to and through the compressors again. The air-flow patterns around the model are studied by means of the schlieren optical apparatus, Fig. 6, which consists of a light source, two 36-in. parabolic mirrors, and a combination viewing screen and camera. (The word "schlieren," borrowed from petrography, means "streaks;" the British therefore simply use the word "striae.") Light from the source, offset to one side, is reflected by one mirror, as a parallel beam, through portholes in line with the model in the test section, to the other mirror on the opposite side, by which it is focused on the camera viewing unit. The light, by a simple adjustment of the knife-edge before the camera, can be rapidly adjusted to reveal even the weaker lines of the air-flow pattern. Photographs are made at will, and automatically, by pushing a button.

FIXED NOZZLE IN BOMB TUNNEL

When a new bomb-tunnel nozzle is first placed in use, flow inclination meters are employed to determine the velocity and direction of air. One such calibration is sufficient.

The test or working section, Fig. 8, of the bomb tunnel is 15 in. × 20 in., and it can take models up to 2 in. diam. The models are made of brass and stainless steel highly polished and sometimes chromium-plated, the better to resist erosion from the cutting action of the high-pressure air stream. They are mounted on the center line of the test section of the nozzle on a strut pointing from the rear. This strut is mounted, in turn, on a balance system which can measure the drag, lift, and overturning moment of the model in the air stream, these reactions being transmitted from the model to the balance system by the rigid strut. This balance system, Figs. 9 and 10, is so designed that the model may be varied through a 20-deg range of angles of attack in order to study the effects of yaw on the aerodynamic characteristics of the projectile. Technically, the balance system is a three-component one-parameter type, which means that it measures in a single plane the three components mentioned.

Windshields isolate from the windstream both the main structural member of the balance, which is a tall thin vertical member downstream from the test section, and also the strut holding the model. The loads transmitted by the strut to the balance system are measured by Tate-Emery units, similar in design to those employed on many materials-testing instruments.

Since air velocities within a wind tunnel depend on the mathematically exact flare of the nozzle as well as on the volume and pressure of the air supplied, the ideal nozzle would be one that is variable between rather wide limits. Fixed nozzles, such as the two used in the bomb tunnel, have a number of disadvantages: (1) The construction of a single one takes a good many months of precision-machining. Each nozzle is extremely heavy and can be mounted in place only by means of some sort of overhead trolley system. (2) Moreover, since it is held in place with many bolts, the slowness of its installation is obvious. This is the only kind of system that has ever been

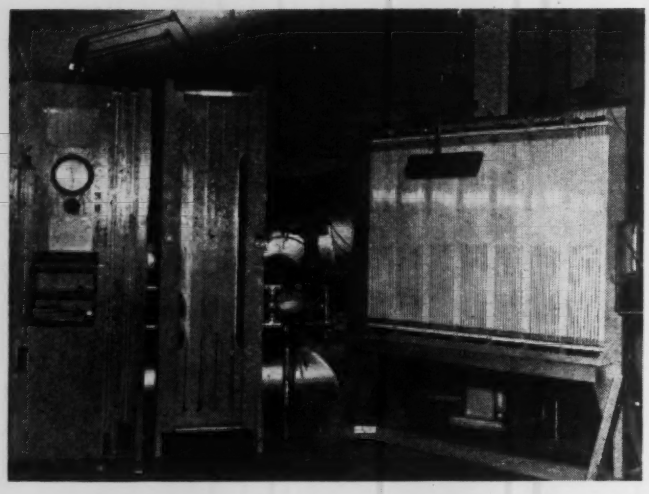

FIG. 4 THE MANOMETER BOARD

used in a supersonic tunnel so that the flexible nozzle now in process of preparation at the Ballistic Research Laboratory represents a new principle in design.

WIDE VARIATIONS POSSIBLE WITH FLEXIBLE NOZZLE

The flexible nozzle, Fig. 3, is quickly variable by the simple process of pressing a number of buttons which set jacks in operation. It is designed for operation at any air speed from subsonic velocities up to velocities of more than 4 times the speed of sound, with one exception, i.e., the transsonic or blind spot mentioned previously. For subsonic velocities, a single converging-nozzle shape suffices. For supersonic air speeds, however, a converging-diverging nozzle must be used. The shape of the nozzle must be different for each different air speed, and its air passage must be formed with extreme accuracy into the shape necessary to provide uniform flow of air, free from interfering shock waves in the test section of the tunnel.

This range of air speeds will be obtained in the variable nozzle by means of an ingeniously designed and operated flexible throat. In the upstream end, it is of rectangular section 15 in. wide and 96 in. high; at the downstream end, where it connects with the test section of the tunnel, the width remains the same but its height may be varied from 14 in. to 22 in. Between the flaring ends there is a narrow throat.

The unchangeable side walls of the nozzle are two flat plates, while the upper and lower surfaces are two flexible steel plates 15 in. wide, fitting snugly across the side walls and obturated by pressurized gaskets. These flexible plates are bent to the desired set of shapes, the upper being a mirror image of the lower, by a series of motor-driven screw jacks attached to the top and bottom of the housing. Electric motors to drive these screw jacks and cause them to operate and produce predetermined curvatures of the plates are set in motion by a set of push buttons. All interior surfaces of the nozzle are chromium-plated to give both hardness and smoothness to increase resistance to erosion and corrosion.

The flexible plates are made by machining $^3/_4$-in. plates to $^1/_4$-in. thickness, leaving integral protruding lugs for the jack attachments. They are then rolled to the shape of an average intermediate curve and heat-treated in a jig. The shape of the nozzle is controlled by a set of cams on a shaft in a control cabinet. Each jack-driving motor is controlled by a servomechanism using a selsyn operated by the cam designed for a desired air speed. The cams direct the individual jack-driving motors to move the proper distance so that the flexible plates are bound into the correct curve for the particular air speed.

AIR-SUPPLY SYSTEM

With these details of the vital mechanism of the two wind tunnels before us, we may consider the supporting and auxiliary equipment, all of which is automatically controlled and all carefully interrelated, Fig. 2. Further, all of it—electrical equipment, motors, transformers, compressors, air driers and filters, reduction gearing, cooling tower, valves, and the like, are commercial types needing little or no modification to adapt them to the work of the laboratory.

Incoming power for the laboratory is a 110-kv 3-phase line. Power is passed through a 110/4.16-kv transformer, oil switches, and other protective devices to the switchboard in the compressor room. Individually driven are five centrifugal compressors, three of which are of the three-stage type, running at 5400 rpm, and each having a rated capacity of 38,000 cfm. The other two are of the four-stage type, operating at 8400 rpm, each with a rated capacity of 11,000 cfm. These five compressors may be connected in parallel or in combination of parallel and series to give compression ratios from 1 to 17. A full series connection is not practicable.

Driving the compressors are three 3000-hp and two 2000-hp 4200-v 3-phase 60-cycle electric motors. The drive is through marine-type, herringbone, speed-reducing gears, operating in reverse in order to increase speed.

Air leaving the compressors is cooled by water in aftercoolers, and the water is cooled in turn by a mechanical induced-draft three-cell cooling tower. From the coolers, the air passes at high pressure through the closed circuit, in which there are 23 valves, some of which are of the cone-plug type and others of the gate type. The average diameter of the valves is 2.5 ft, and they are operated by push-button-controlled motors.

Flowing through the nozzle, where its velocity is increased for tests in the supersonic ranges, the air stream passes the model and the windshield-protected balance system in the test section. The forces exerted upon this device are carried hydraulically to a switchboard and meters which are calibrated to read directly the lift, drag, and moment in pounds and inch-pounds, Fig. 2, item *G*.

Leaving the test section, the stream of air goes into the diffuser. There its velocity is lowered, as the diffuser changes the velocity head to a pressure head, and the circuit is completed when the air reaches the compressors once more.

The temperature of the air stream in the test section of the bomb tunnel is about —100 F, for Ma 1.7, and will be about —300 F, for Ma 4.4 in the ballistic tunnel. However, the walls of the tunnels are separated from the air stream by the "boundary layer," a thin stratum of air through which the velocity decreases and the temperature increases, approaching stagnation temperature at the walls themselves. Owing to heat transfer, the wall temperatures actually read below the stagnation points; for example, the walls of the bomb tunnel, when the fixed nozzle for Ma 1.7 is in use, are about 50 F.

FIG. 5 THE CONTROL DESK, SERGEANT PLATO ON DUTY

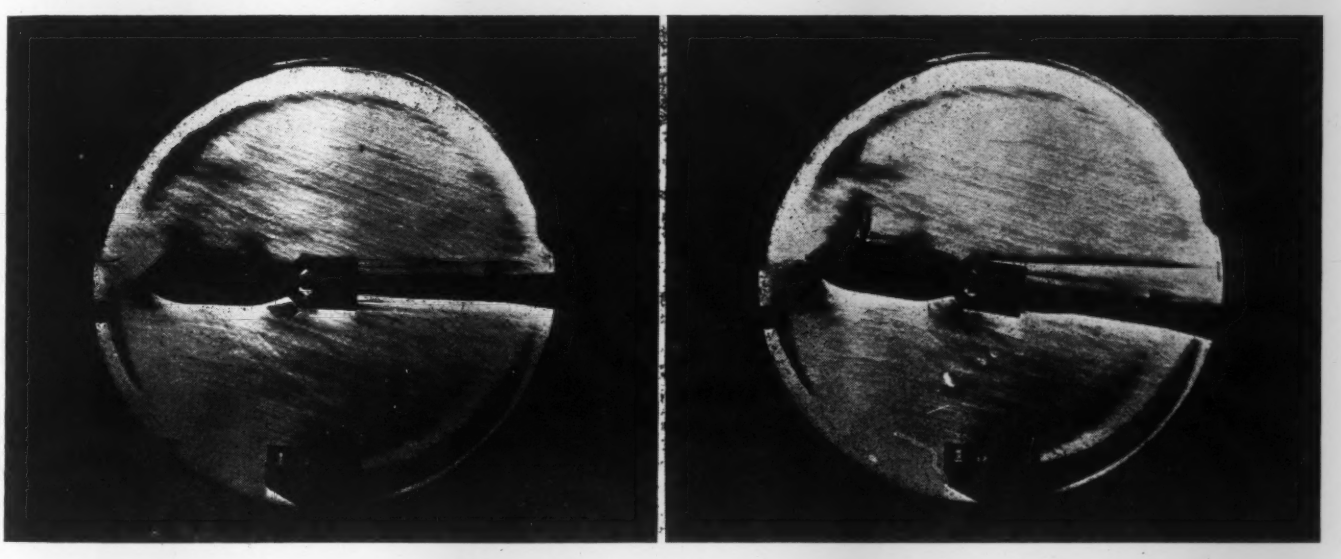

FIG. 7 RESULTS OF BOMB MODEL TESTS AT DIFFERENT ANGLES OF ATTACK

In order to attain a different air density in the closed circuit, there must be some means of varying either the volumetric size of the circuit itself or of the quantity of air it contains. Since size is fixed, a method of changing the quantity of air is provided by a 32-ft spherical tank behind the wind-tunnel building. This sphere, item *A*, Fig. 2, was constructed and installed by the Pittsburgh-Des Moines Steel Company which also erected the building and constructed and installed the bomb tunnel. In this sphere, air is maintained at a pressure of 75 psi. When a test is to be made at a different air density, tables indicate to the scientists in charge the quantity of air which should be in the entire tunnel system, and the reserve supply is then drawn upon for the necessary amount.

Due to erosive action of high-velocity air, it is necessary that the stored air be dry and free of dust. Particles of dust would act upon the walls of the tunnels like a sandblast, and moisture would cause trouble by introducing condensation shocks and by frosting parts of the system and the model itself. Hence as air is pumped into the sphere by a 60-hp horizontal compressor, it is passed through a drier of the activated-alumina type and finally through a filter into the sphere.

EARLY STAGES IN AMERICAN WIND-TUNNEL DEVELOPMENT

Conception of the supersonic wind tunnels had its roots in nearly a half century of research. Besides Mach's contributions, the next known work appeared in France in 1916, during World War I, and was developed under guidance of the Gavre Committee. Supersonic ballistic studies were then principally concerned with the resistance of projectiles. By 1917, Hugenard had installed a high-velocity free-jet wind tunnel at Paris, with a speed of Ma 1.2. His project, however, was abandoned with the signing of the Armistice. Its description and a report on its results were made later by Lieut. S. Sewall, U. S. Army.

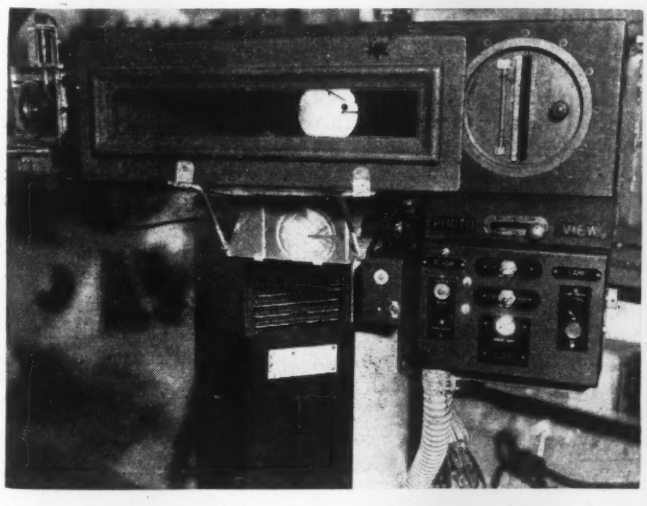

FIG. 6 SCHLIEREN CAMERA AND CONTROL PANEL

Among the first efforts in the United States along this line was that conducted for the Army Ordnance Department between 1918 and 1926, by Dr. H. L. Dryden of the United States Bureau of Standards. His was a more or less continuous program of research in bomb ballistics, but it employed low wind velocities of 100 and 200 fps. Most of the work dealt with a general program of wind-tunnel investigation for bombs ranging from 100 to 2000 lb. The Bureau of Standards provided a 4.5-ft tunnel, using models 4 in. in diam at angles of yaw from zero to plus 20 deg. Dr. Dryden's investigation contributed materially during 1922 and 1923 to the development of new methods of bomb design.

Also during the period 1920–1923 Major G. F. Hull, Army Ordnance Department, and Dr. L. J. Briggs, of the Bureau of Standards, conducted experiments at the General Electric Company plant at Lynn, Mass. They were interested in determining drag and skin friction of projectiles. Their models varied in diameter between 0.5 in. and 3.97 in., and the air-jet or nozzle diameters were 6, 7, and 12.24 in., respectively. Air velocities could be produced up to about 1600 fps. The Lynn tunnel also used some spheres and bomb models, but the results obtained were inconclusive.

Major Hull and Dr. Briggs turned to Edgewood Arsenal, Md., during 1924 and 1925. There the wind tunnel was equipped with a 2-in. air stream, operating up to about 1600 fps. Models were 0.5 in. to 0.75 in. diam, but apparently proved too large for good test results with the size of air stream available. Data obtained at both Lynn and Edgewood Arsenal were used to check the effect on air resistance of the position of the rotating band with relation to the base of the projectile, as compared with the values obtained from the firing.

EUROPEAN DEVELOPMENTS IN WIND TUNNELS

In Europe supersonic wind tunnels were constructed about 1928, at Göttingen and at Zurich. The Zurich tunnel was of the continuous-operation type with velocities up to Ma 2, but the Gottingen tunnel could only be operated intermittently because it was based on the vacuum-tank principle. In this system, air was evacuated from a large tank, and then more air was permitted to rush into the tank through the test section

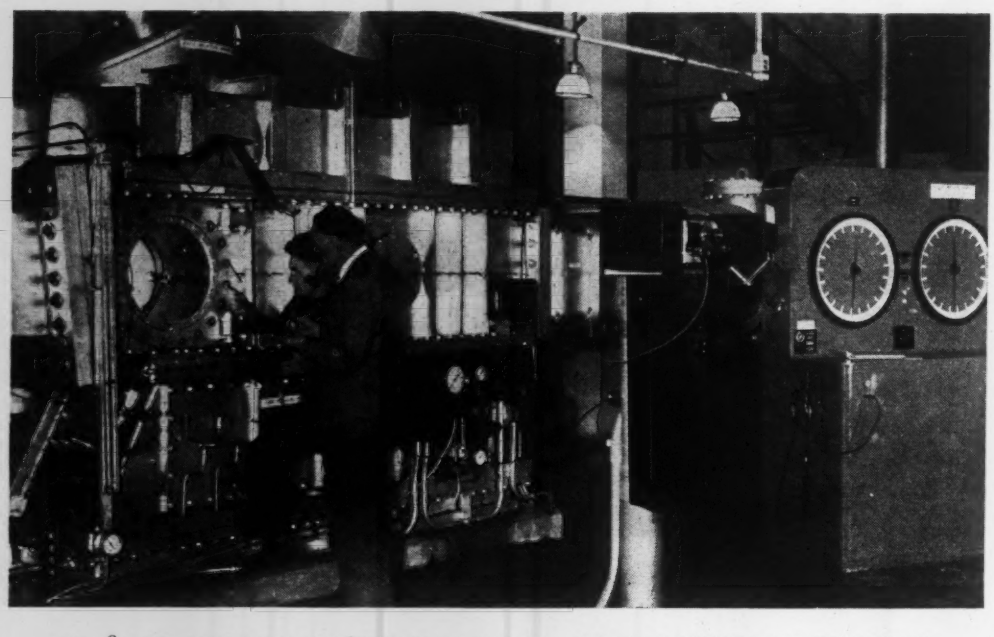

FIG. 8 THE TEST SECTION OF THE BOMB TUNNEL; LIEUTENANT CONTI AND DR. HUBBLE

containing the test model. In a very few seconds the tank was restored to atmospheric pressure and the test was interrupted until a vacuum could be produced by pump again. This tunnel had two sizes of working sections. They were 4 in. × 4 in., with a 25-sec flow, and 8 in. × 8 in., with a 5-sec to 6-sec flow. The speeds were Ma 1.39 and Ma 3.16, respectively. Eight years later, in 1936, the Aerodynamic Institute of the Technischen Hochschule, at Aachen, installed a supersonic wind tunnel similar to the intermittent type at Göttingen.

Italy installed a continuous-operation type about 1930, at Guidonia. It had a working section 12 in. × 15 in., with Mach numbers up to 1.75.

England, during the early 1930's, converted an old 3 × 4.5-in. tunnel into one with speed of Ma 2. With the advent of World War II, however, the National Physical Laboratory, England, set up a supersonic tunnel with working section 11 in. × 21 in., and air velocities up to Ma 2.7.

By the time the United States entered World War II, this country was virtually the only major power without a wind tunnel capable of use for high-velocity ballistics studies.

Germany had at least three laboratories, besides the one already mentioned at Göttingen, and plans for more. Most complete was the Wasserbau Versuchs Anstalt at Kochel, although it was limited by type of construction and power available. It was of the suction type, operated by a large evacuating storage tank, and therefore intermittent in flow. Each of three 6000-v 270-kva induction-type motors drove a pair of rotary-vane-type compressors with total capacity in parallel of about 42,000 cu m of air per hr, or 24,700 cfm at the intake. Because of the short operating time between each evacuation of the storage tank, it was possible to test only one force component per run. In testing the usual three force components, i.e., drag, lift, and overturning moment, it was necessary to make six test runs for each angle of attack, since a "no-load" test must be made before each load run.

At Luftfahrt Forschungs Anstalt, Brunswick, the Germans had three wind tunnels, two of which tested mostly at subsonic speeds. Apparently there was such a demand for equipment elsewhere that technicians could not properly complete these tunnels for supersonic testing. The one tunnel that tested above sonic speeds was designed for continuous operations from a compressor system.

The third laboratory, Luftfahrt Forschungs Anstalt at Munich, was apparently not completed for use. It was planned somewhat as an extension to facilities at Brunswick.

Reports indicate that the Germans planned an ambitious program, with a proposed tunnel 1 meter square. Its elaborate drive system was to comprise six axial compressors and four centrifugal compressors arranged in seven stages, the first four driven by water turbines and the other three electrically driven.

From this it is apparent that the Germans had committed themselves to the expenditure of large amounts of money and energy in the field of supersonic flow research. Although there was much equipment nearly ready for routine testing, the Kochel and Göttingen plants were the only ones actually conducting any large number of supersonic tests. The Kochel plant was essentially a simple installation. The work done was distinguished not so much by new principles or advanced methods, as by energy, patience, and perseverance.

It is expected that the Allied Nations can obtain some benefit from the German work in a study of their experimental results and of their experimental techniques and methods. Some of the German equipment probably will be used elsewhere, but it is expected that in most cases better results will be obtained from newer designs based on American experience already accumulated in the field.

Besides ballistic wind tunnels in England, Germany, and Italy, there was also one in France. Although very little information is available at present, its nozzle size is believed to be less than 10 cm square, and it had no balance for reading forces. Japan, too, was reported to have a supersonic wind tunnel for testing projectiles, but information is indefinite.

INCEPTION OF THE ABERDEEN TUNNEL

American Army Ordnance had long been interested in a ballistic wind tunnel. About 1938, discussions between Col. H. H. Zornig then Director of the Ballistic Research Laboratory, and his staff with the Scientific Advisory Committee of the laboratory, especially Prof. Th. von Kármán, showed the great desirability of having the facilities of a supersonic wind tunnel available for research in exterior ballistics for use in connection with the design of improved and more efficient ballistic shapes, and for the expeditious production of firing and bombing tables. Further light was thrown on the problem and the need for such a tunnel, or tunnels, stressed in a paper,[2] written in 1939, by Dr. von Kármán in his capacity as director of the Daniel Guggenheim Aeronautical Laboratory of the California Institute of Technology.

As a consequence, this office called upon the National Academy of Sciences to appoint a competent committee for the purpose of studying the feasibility of constructing a supersonic wind tunnel. Under the chairmanship of Dr. William F. Durand, the committee reported that such a tunnel appeared to be feasible, economical, and in the interest of the United States.

It was fully realized that the construction of a large super-

[2] "Proposal for a Superspeed Wind Tunnel at the Guggenheim Aeronautical Laboratory of the California Institute of Technology," by Dr. Th. von Kármán, director of the Laboratory, 1939.

sonic tunnel (a project not previously attempted) presented a research project in itself. Experimental techniques, optimum model sizes, and other data pertaining to tunnel operation were not then known and had to be developed. Accordingly, the Ordnance Department proceeded by first constructing a model tunnel of small but workable size at the California Institute of Technology under a National Defense Research Committee contract. That model tunnel, developing a maximum velocity of Ma 4, was completed and furnished a large part of the design data for the present supersonic wind tunnel.

After successfully operating the model tunnel for about a year, the Ordnance Department proceeded with construction of the full-scale tunnel. This contract was carried out by the Pittsburgh-Des Moines Steel Company as architect-engineer manager for the construction of the tunnel. Under this contract, this company managed the construction phases of the work, and the staff of the Ballistic Research Laboratory supplied a large part of the scientific competence for achieving the task.

The bomb tunnel was completed and calibration tests of it were begun in December, 1944. A month later the Ordnance Department engaged in its first bomb-tunnel model tests. In May, 1945, the Supersonic Wind Tunnel Laboratory was officially dedicated.

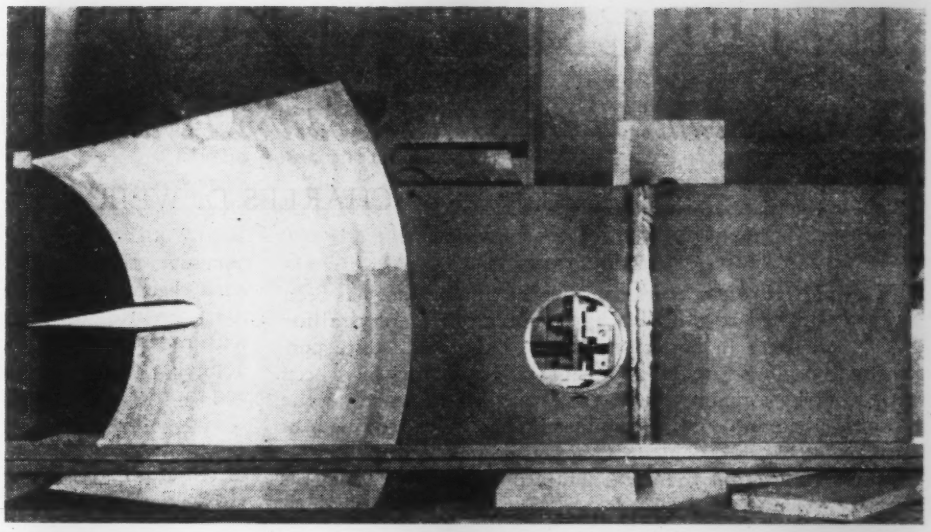

FIG. 10 BALANCE SYSTEM OUTSIDE OF TUNNEL

TUNNEL HAS JUSTIFIED ITS COST

The original cost of this facility was more than repaid in the first bomb tests conducted in the bomb tunnel. This happened when an urgent call came from fighting theaters for a new bomb, and the Army needed the facts on a new bomb design.

"In less than a day after a model was made," reported Dr. Edwin P. Hubble, Chief of the Exterior Ballistics Branch of the Ballistics Laboratory, "the tunnels proved the bomb design would not be successful; and even more important, within two days tunnel tests revealed modifications of the initial design that would make it successful." The tunnel had given data in a matter of days that would have required long months of bomb manufacture, test by regular bombing, redesign, more manufacture, and more testing had Ordnance carried out the tests by older methods. That Army strategy did not have to wait so long for the bombs it needed—with all the battle success and saving in the lives of men that this fact implies—points to an obviously vital accomplishment.

That was months before VE-Day. Every advance in bomb design then meant a shortening of the war. Other advances were made—many of them—for the bomb tunnel was operating continuously, from the beginning to VJ-Day. Much of the time, there was two-shift operation. Add up the data obtained in that time, when one bomb test or bomb-fin test takes just about an 8-hr day—and there can be no question of the contribution to victory by this one tunnel.

Specific projects investigated to date in the bomb tunnel cannot yet be made public. High on the list are the testing of bombs and artillery shells and the modification of their designs before production. Basic aerodynamic studies of projectiles, both fin-stabilized and spin-stabilized, are also being made continually. For both the Army and the Navy, the laboratory has conducted studies on long-range rockets and guided missles.

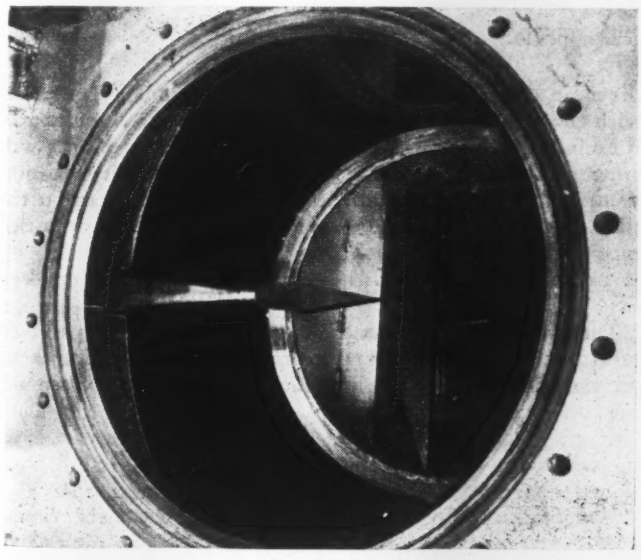

FIG. 9 BALANCE SYSTEM INSTALLED IN TEST SECTION

FUTURE INDUSTRIAL USES

The wind-tunnel scientists at Aberdeen have gone outside the ballistic field in their studies. Already, several tests have been run in connection with high-speed aircraft in cases requiring greater wind velocities than those obtainable in existing aerodynamic wind tunnels. These have concerned basic designs of such parts as airfoils, tail assemblies, and wings. Some work also has been done along general test lines, including the calibration of Pitot tubes used in velocity readings in other wind tunnels.

Such work gives a hint of possibilities for future use of the laboratory at Aberdeen. Obviously, it will be necessary to continue the study of bomb and projectile design in the years to come, but these studies during peacetime will be neither as numerous nor as pressing as they were. Therefore, the wind tunnels should be available for tests of many types of commercial products in which air flow is involved. Airplane propellers, for example, and turbines offer problems, the solution of which requires experimentation at air speeds beyond the reach of any other tunnel now in operation. Turbines offer the most significant field. The Ordnance Department ballisticians believe that such commercial tests, all carried out in the interest of

(*Continued on page 835*)

INTERCRYSTALLINE CRACKING

The Significance of the Silica - Sodium Hydroxide Ratio in Boiler Failure

By CHARLES D. WEIR[1]

INTRODUCTION

WITHIN recent years considerable importance has been attached to silica as a promoter of intercrystalline cracking in boiler seams.[2,3] Laboratory tests purporting to demonstrate the detrimental effect of silica have been carried out by a number of investigators but in so far as the author is aware, no critical examination has as yet been made of the relevant data available from actual boilers.

In this connection the data obtained by Partridge and his associates,[4] using the Schroeder detector, are of particular importance. These authors present their data in the form of a series of dot diagrams in which the abscissas represent pressure p, and the ordinates some measurable characteristic c, of the feedwater employed. The distribution of cracked boilers with respect to the two variates p and c is represented by a "population" (in the statistical sense) of black dots, while the distribution of uncracked boilers is represented by a population of white dots. Evidently these populations may be regarded as random samples of the infinite populations from which they are drawn.

For our present purpose, which is to measure statistically the effect of the silica-sodium hydroxide ratio on the susceptibility to cracking, only Fig. 1 of the present paper, which shows Figs. 3 and 4 of the original paper,[4] need be considered. Fig. 3 represents the distribution of cracked and uncracked boilers with regard to pressure p, and sodium-hydroxide concentration C, while Fig. 4 represents the corresponding distribution with regard to p and the silica-sodium hydroxide ratio R. We designate the data represented by the former diagram as set A and that represented by the latter as set B.

The data of set A are distributed according to the values assumed by the variates p and C, and hence represent a random distribution with respect to R, since no correlation exists between R and C. On the other hand, a subset B^1 is selected from set B having an arbitrary mean value $\bar{R}$ of R. Thus if the highly improbable occurrence of a fortuitous coincidence of the mean and variance of the random distribution of R in set A with the arbitrarily selected mean and variance of subset B^1 is excluded, it may be expected that the two sets of data will differ significantly in the statistical sense.[5] If they do not, then it will be a legitimate deduction from the data that the silica-sodium hydroxide ratio is not a significant factor in this type of boiler failure.

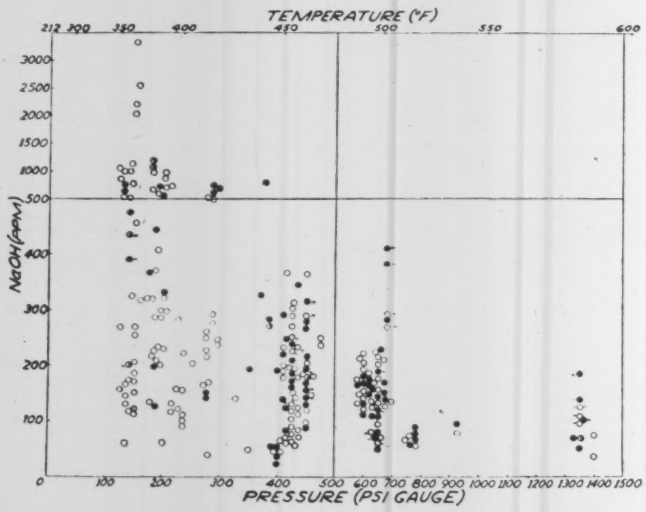

FIG. 3 INCIDENCE OF CRACKING RELATED TO CONCENTRATION OF SODIUM HYDROXIDE

(Cracking may occur with as little as 50 ppm, or may not occur with as much as 3000 ppm of NaOH.)

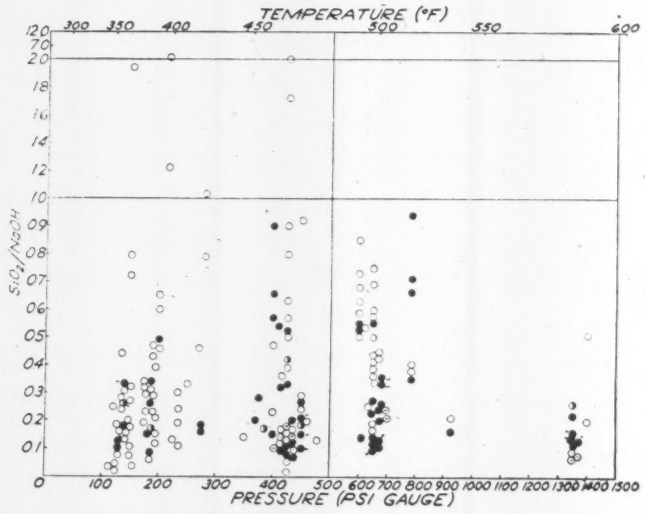

FIG. 4 INCIDENCE OF CRACKING RELATED TO RATIO OF SILICA TO SODIUM HYDROXIDE

(Cracking occurred with values of $SiO_2/NaOH$ in the broad range from 0.1 to 1.)

FIG. 1 CHARTS USED FOR STATISTICAL ANALYSIS OF EFFECT OF SILICA - SODIUM HYDROXIDE RATIO ON SUSCEPTIBILITY TO CRACKING IN BOILER SEAMS

(Footnote 4, Figs. 3 and 4, p. 419.)

EXTRACTION OF NUMERICAL DATA

The two sets of data, A and B^1, are grouped according to temperature θ, with a grouping interval of 50 deg F, and an arbitrary origin at $\theta = 375$ F. The independent variate, corresponding to temperature is therefore

$$x = \frac{\theta - 375}{50}$$

Grouping according to temperature is more reasonable chemi-

[1] Bachelor of Science, Research Student, James Watt Engineering Laboratories, The University, Glasgow, Scotland.

[2] "Effect of Solution Composition on the Failure of Boiler Steel Under Static Stress at 250 C," by W. C. Schroeder, A. A. Berk, and E. P. Partridge, Proceedings, A.S.T.M., vol. 36, Part 2, 1936, p. 721.

[3] "Boiler Water Treatment," by F. G. Straub and T. A. Bradbury, MECHANICAL ENGINEERING, vol. 6, 1938, pp. 371–376.

[4] "Field Data From the Embrittlement Detector," by E. P. Partridge, C. E. Kaufman, and R. E. Hall, Trans. A.S.M.E., vol. 64, 1942, p. 417.

[5] That this contingency does not arise in the subsequent calculations has been checked by the selection of a further subset having a mean differing from that of B^1.

cally than grouping according to pressure, and has the additional advantage of giving a larger total in the higher groups where the distribution is less dense.

In grouping set A, the sodium-hydroxide content of the feedwater has been ignored. This procedure is justified, since the means of the sodium-hydroxide concentrations of the cracked and uncracked boilers do not differ significantly. As Partridge and his associates have pointed out, this result is to be expected in view of the manifold concentration which takes place within the seam. As has already been mentioned, however, an arbitrary mean value of R must be selected in grouping set B; we choose $\bar{R} = 0.2$ with maximum deviation ± 0.2.

Next, in each group we count the total number of boilers and the number cracked, and calculate the proportion, number cracked to total number, which is then entered in the appropriate column, p_A or p_B of Table 1.

TABLE 1 NUMERICAL DATA

Scheme:

θ deg F	x	p_A	p_B	$p_B - p_A = Y$
375	0	0.2358	0.2500	0.0142
425	1	0.3600	0.2222	−0.1378
475	2	0.4400	0.4792	0.0392
525	3	0.5909	0.6492	0.0583
575	4	0.5714	0.6000	0.0286
$N = 5$	$\bar{x} = 2$	0.4396	0.4401	$\bar{Y} =$ 0.0005

$$r_1 = \bar{Y} = 0.0005$$

$$\Sigma\{(x - \bar{x})^2\} = 10, \qquad \Sigma\{Y(x - \bar{x})\} = 0.2249$$

$$r_2 = 0.02249$$

$$\Sigma\{(Y - \bar{Y})^2\} = 0.02478; \qquad r_2^2\Sigma(x - \bar{x})^2 = 0.00517$$

$$\Sigma\{(Y - Y)^2\} = 0.01984$$

$$S^2 = 0.00661.$$

$$\frac{S^2}{(x - \bar{x})^2} = 0.000661 = (0.02572)^2$$

$$t_1 = \frac{0.0005\sqrt{5}}{\sqrt{0.00661}} = 0.0138; \quad n = N - 2 = 3$$

$P > 0.9$, from Fisher[6]

$$t_2 = \frac{0.02249}{0.02572} = 0.8745; \quad n = 3$$

$0.4 < P < 0.5$, from Fisher[6]

Some error is, of course, incurred by grouping what are in reality continuous variates and by arbitrarily locating the group values at the centers of the groups. These errors are, however, not large and in a test for significance may be ignored.[6]

ANALYSIS OF THE DATA

From the tabulated data, Table 1, it may be observed that p_B appears to be somewhat larger than p_A, and that, moreover, the difference appears to increase with temperature. It is necessary to determine whether these deviations merely represent errors of random sampling, or whether they indeed represent true differences in the parent populations.

The method adopted was to fit a "regression line" to the differences $(p_B - p_A)$ and test the coefficients for significance by means of "Student's" t-distribution on the hypothesis that the deviations are attributable to chance.

Now a mathematical relationship exists between the statistic t and the probability P, that the divergence of the regression coefficients from their hypothetical values represents a chance error. A table of P corresponding to different values of t has been published by Fisher.[7] In biological work it is customary to assign a limit $P = 0.05$, below which the hypothesis being tested cannot be regarded as satisfactorily accounting for the facts. We may conventionally adopt the same boundary value.

The computational work involved is shown in the accompanying scheme, but for details of the arithmetical methods used the reader is referred to the work of Fisher[6] already cited.

The P values obtained clearly show that the hypothesis fits the facts. There is therefore every justification for stating that the silica-sodium hydroxide ratio cannot be regarded as having a significant influence on the susceptibility of boilers to intercrystalline cracking.

[6] "Statistical Methods for Research Workers," by R. A. Fisher, ninth edition, Oliver & Boyd, Ltd., London, England, 1944.

Supersonic Wind Tunnel Laboratory

(*Continued from page 833*)

American industrial progress, may be conducted in increasing numbers in the future.

Those who have contributed to the Supersonic Wind Tunnel Laboratory have helped to place the Ordnance Department in a highly advantageous position for fundamental studies in ballistics which will push back the frontiers of the unknown. This valuable facility will be available for research not only by the Grdnance Department and other military agencies of the Government, but should contribute significantly to advancement of research in the peaceful pursuits of American technology and American industry in general. In this laboratory we have a facility born of the needs of war but which will also advance our status in the cause of peace.

ACKNOWLEDGMENT

Some of the contributors to this outstanding project have been mentioned already in connection with its history. These and many others contributed wholeheartedly to it at a time when the nation needed their knowledge and ability. Among these is Dr. Edwin P. Hubble, noted astronomer at Mount Wilson Observatory, who took war leave to become Chief of the Exterior Ballistics Branch of the Ballistics Research Laboratory under direction of Col. Leslie E. Simon. The laboratory staff includes a large number of skilled civilian scientists and Ordnance officers. Not to be overlooked is that group of operating personnel, privates, corporals, and sergeants, who help to conduct the tests, take the readings, and work out the mathematical data from them; graduates of larger universities, some of these are doctors of philosophy, masters of science, or have other high degrees.

The Ordnance Department has been fortunate in having the advice and guidance of a group of the country's leading scientists who constitute the Scientific Advisory Committee of the Ballistic Research Laboratory. This group meets with the Ordnance Department scientists two to four times a year, without remuneration, to make over-all evaluations of the work of the laboratory, assist in the formulation of policies, and guide further ballistic research.

The committee is made up at present of the following: Mr. Paul L. Alger of the General Electric Company; Prof. J. W. Beams of the University of Virginia; Dr. Hugh L. Dryden of the Bureau of Standards; Dr. W. W. Hull of the General Electric Company; Dr. Th. von Kármán of California Institute of Technology; Prof. George B. Kistiakowsky of the National Defense Research Committee; Dr. Charles C. Lauritzen of California Institute of Technology; Dr. Bernard Lewis, formerly of the Bureau of Mines, now a Lieutenant Colonel in the Office, Chief of Ordnance; Prof. J. Von Neumann of the Institute for Advanced Study, Princeton, N. J.; Prof. I. I. Rabi of Columbia University; Prof. Henry Norris Russell of Princeton University; and Prof. Harold C. Urey formerly of Columbia University, now director of the Institute of Nuclear Research, University of Chicago, Chairman of the Committee.

ECONOMIC MATURITY AND BUSINESS PROSPERITY[1]

By DONALD S. TUCKER

MASSACHUSETTS INSTITUTE OF TECHNOLOGY, CAMBRIDGE, MASS.

As a nation grows richer, its annual savings increase. The problem of finding adequate investment outlets for these savings becomes therefore more acute. Some students have even concluded that investment opportunities cannot be found in adequate volume, and that the United States will therefore be confronted by the need for recurring and perhaps almost continuous federal deficits if business prosperity is to be maintained. A pamphlet criticizing this pessimistic philosophy was reviewed in the December, 1939, issue[2] of MECHANICAL ENGINEERING. Now the publishers of that pamphlet have presented a book which was prepared for them by George Terborgh.[3]

Mr. Terborgh's book is a contribution to the theory of the business cycle. Explanations of cyclical recessions have been of many kinds. Relative satiation of consumers' desires, changes in the margin between prices and costs, and variations in the need for and supply of bank credit have each played their roles; but during recent years a growing body of opinion has come to regard the relation of saving to investment as the factor of prime importance. To this modern school Mr. Terborgh clearly belongs. He would agree that, if saving tends to outrun investment, the national income will diminish. He questions only the necessity of such a condition; but, before his argument can be examined, it will be helpful first to dispose of a minor problem in connection with definitions.

MINOR CONTROVERSY OVER DEFINITIONS

Among students of saving and investment one group has maintained that saving is necessarily equal to investment. This view is correct provided an enlargement of the saver's bank account may be considered an investment. If investment is defined so as to include these cash balances, then saving is but another name for investment, and we must attribute the subsequent shrinkage of the national income to a mere tendency of the saving aspect to outrun the investment aspect. Though this concept of investment has a priority in time, its use conceals the existence of certain factors whose importance is clearly revealed by the adoption of a more recent set of concepts.

The second school would say that wages, rents, dividends, and other incomes are paid with revenue money and that ordinary goods also are purchased with revenue money. Money therefore must be divided into two classes: (1) Revenue funds or money which is available for buying the products of current production; and (2) capital money which is not available for such use. Financial saving, the only kind significant here, consists of receiving revenue money and converting it into capital funds which are available only for purchasing securities or claims to goods produced in other periods. Investment consists of taking capital money and converting it back into revenue funds by using it to buy labor, materials, or similar currently produced goods. Revenue money facilitates both current production and current consumption as long as it retains its character as such. It loses its potency only when converted into capital funds.

Because each dollar of revenue money is normally spent by successive owners many times within a year, and because some portion of each spending becomes income to someone, we find that the national income in any year will be several times as large as the average amount of revenue money available during the year. This relation of the national income to the volume of revenue funds is called the "income velocity" of revenue funds. If this income velocity is 3.9, then an excess of investment over saving, if it expands revenue funds (and diminishes capital money) by one billion dollars, will enlarge the subsequent national income by 3.9 billion dollars per year. The second set of definitions thus throws the nature of the investment problem into sharp relief; but the acquisition of capital money is not treated as an investment by this school. If, then, this second set of definitions is used, the amount of investment in any year may differ greatly from the amount of saving. Equality can happen only by accident. Differences between saving and investment alter the magnitude of revenue funds; and the magnitude of revenue funds determines directly the size of the nation's money income.

Mr. Terborgh has unfortunately chosen to use the first or older set of definitions, and this choice may make his book rather more difficult for some readers. The second or newer set of definitions will therefore be used in this review. Whatever the definitions used, the real problem is to determine the reason why saving may outrun (or tend to outrun) investment. On this point there are three schools of thought, each offering a different reason for this phenomenon. The existence of differences of opinion within the savings-investment school of business-cycle theorists provides the occasion for Mr. Terborgh's book.

THREE VIEWS OF BUSINESS RECESSION

One view is that during business prosperity the pace of investment exceeds the pace of saving. Capital money is thus diminished: revenue funds and income are enlarged. This enlargement of consumer income during prosperity operates to create ever more opportunities for profitable investment. Excess of investment over saving also depletes the reservoirs of capital funds. These reservoirs include security dealers and private investors as well as the lending departments of banks. Depletion of these reservoirs operates finally to increase the amount of capital money that is needed by businessmen for their current financing. As long as banks and the financial markets hold ample capital funds, a dollar may, within a single year, serve in turn the seasonal needs of several producers; but when these pools are so depleted that the use of pool money becomes either expensive or dangerous, then this possibility of successive use disappears.

Capital money to the amount of $150,000 may finally become necessary in order to provide three entrepreneurs with $50,000 each. While successive use was still possible, only $50,000 might be needed in order to provide each of three entrepreneurs with $50,000 for seasonal use. In order to acquire some part of this extra $100,000 of capital money, entrepreneurs will liquidate tangible assets. Such liquidation converts revenue money

[1] One of a series of reviews of current economic literature affecting engineering prepared by members of the Department of Economics and Social Science, Massachusetts Institute of Technology, at the request of the Management Division of THE AMERICAN SOCIETY OF MECHANICAL ENGINEERS. Opinions expressed are those of the reviewer.

[2] "Uninvested Savings," by Donald S. Tucker, MECHANICAL ENGINEERING, vol. 61, 1939, pp. 907–908.

[3] "The Bogey of Economic Maturity," by George Terborgh, published by Machinery and Allied Products Institute, Chicago, 1945.

into capital funds and diminishes the national income. This diminution of consumer income then diminishes the opportunities for profitable investment. After business recession has set in, the opportunities for profitable investment do indeed disappear; but such disappearance is—according to this first view—a result of business depression as well as a cause of its prolongation. Business recession—according to this first view—is caused by excessive investment opportunities during business prosperity and by consequent depletion of capital funds.

Investment may be prevented either by the lack of a profitable opportunity or by lack of the capacity to finance an investment. According to this first view the lack of profitable opportunities is important only after recession has begun; the downturn which terminates prosperity is due to a lack of the capacity to finance further investment.

A second view, which has been associated especially with the name of Professor Hansen, is in some respects diametrically opposed to the first. The declining growth of population, the passing of the frontier, and the dearth of great new industries have—according to this second view—diminished total opportunities for investment, while better accounting for depreciation and more careful administration of corporate income have enlarged the savings made by corporations. These influences have all operated to narrow the outlets available for the use of personal and family savings. Occasionally—as during the twenties—the growth of an automobile industry or other influences may provide an adequate field for investment, and business will then prosper; but such prosperous periods will be the exceptions rather than the rule. In the absence of deficit spending by governments, we must look forward to prolonged periods in which investment will be small and income will therefore be small. Saving will be rendered equal to investment because income will diminish until savings are cut down to the required size.

According to all three views an excess of saving over investment will cause subsequent diminution of the national income; but according to this second view the amount of investment is limited by a chronic lack of investment opportunity. A deficit of investment opportunities is then the essential element of this second philosophy, and it is this second or "stagnationist" philosophy which Mr. Terborgh attempts to refute.

A third view, to which Mr. Terborgh apparently subscribes, is that investment opportunities are normally abundant, but occasionally, as in 1929, some peculiar condition may cause such opportunities to be temporarily inadequate. If opportunities are lacking, investment and income will of course decline; but the lack of adequate opportunities for profitable investment is regarded as exceptional and arising only from some special combination of circumstances. Mr. Terborgh does not develop the constructive view imputed to him here. He is interested only in attacking the stagnationist philosophy. His book is a polemic. It is important because it is a direct attack in book form upon the Hansen or stagnationist philosophy.

Though there would be genuine differences in the wording used, all three of the foregoing philosophies would agree substantially that the decline of income which constitutes business recession is due to a condition in which liquidation and saving diminish revenue money more rapidly than such money is replenished by investment and deficit spending. They differ only as to the reason for this condition. The second and third philosophies are alike in that they regard the supply of capital money as always adequate for all needs, and they emphasize therefore the haphazard fashion in which technical progress creates new outlets for savings. In the second and third philosophies then a lack of profitable opportunity is the only significant reason for a decline of the pace of investment. The first philosophy, on the other hand, maintains that during prosperity the expansion of consumer income actually creates new opportunities, and that the downturn is initiated solely by financial influences. The first and third philosophies are therefore alike in their optimism. Mr. Terborgh's book supports the first theory as fully as it supports the third. It is designed only to refute the second or stagnationist view. The several steps of his argument may now be summarized.

DECLINING RATE OF POPULATION GROWTH

Chapter 1 of Mr. Terborgh's book presents reasons why many business men accepted the stagnationist philosophy. Chapter 2 describes this philosophy. Chapter 3 attacks the idea that a declining rate of population growth will check investment and income. Changes of population in various countries and at different periods are compared with changes in production per capita. No correlation is found. It is unfortunate that Mr. Terborgh does not present figures as well as charts. Business prosperity may be measured by an index consisting of total production divided by secular trend. Total production divided by population (the figure used by Mr. Terborgh) is a better measure of welfare; but the one measure cannot be converted readily into the other. One of Mr. Terborgh's charts shows that in Sweden the increase of production per capita was greatest when the increase of population was least. This suggests strongly that the expansion of production proceeded without regard to changes in the growth of population. If the expansion of production is in fact not affected by changes in the rate of population growth, the first pillar of the stagnationist philosophy is demolished.

Chapter 4 describes ways in which a diminution of the rate of population growth operates to diminish also the net amount of family saving. Aged and retired persons form a larger percentage of a stationary than of an expanding population. Aged and retired people tend to spend their savings. A few fortunate individuals may live on interest and dividends when personal earnings cease. Others by spending their principal diminish the net amount of family saving for which investment outlets must be found.

OTHER BOGEYS

The passing of the frontier (chapter 5) occurred in the eighteen-nineties. Because of the definiteness of the timing of this influence, the argument on this point can approach more closely to proof than is possible in other connections. It does seem that, if the passing of the frontier had been a cause of business depression, this depression would have happened in the first decade of this century rather than in the fourth.

The third "bogey" or pillar of the stagnationist philosophy (chapter 6) is the present dearth of great new industries. There can be no doubt that in earlier decades the development of the canal, the railroad, and the automobile provided investment opportunities in many lines in addition to the opportunities created within these specific industries. It is not certain that any of the industries now new will become equally great or fertile; but the greatness and fertility of the canal, the railroad, and the automobile industries could not have been foreseen when they were new. Stagnation has been predicted before this. The number of industries making technical progress now is very great. Many new opportunities are being created by research in housing, plastics, and other fields. These industries collectively may perhaps give rise to opportunities greater and more constant than those provided by the canal, the railroad, or the automobile.

Widespread improvement of accounting procedure may have caused corporations to save a larger percentage of their incomes, and such corporate saving would of course narrow the field open for the investment of family and personal savings. Chapters 7 and 8 in attacking this idea set up a straw man for subsequent attack. These chapters are therefore perhaps the least valuable in the whole book; but Chapter 9, "The Internal Financing of Corporations," reveals clearly how difficult it is to make satisfactory comparisons in this field. In the nineteenth

century much accounting was primitive. Improvements were often charged as expense. It is by no means certain that business now finances internally a larger percentage of its expansion than it did during the nineteenth century.

MR. TERBORGH'S CONCLUSIONS

Chapter 10 is devoted to a history of saving and investment; but in chapter 11 Mr. Terborgh reviews the causes of the Great Depression and presents, on pages 184–185, some of the arguments used by those who believe that business recession is caused by an exhaustion of capital funds rather than by a lack of opportunities for profitable investment. His analysis here is brief. He is much less interested in the causes of the recession of 1929–1932 than he is in refuting the idea of a general or permanent deficit of investment opportunity.

Chapter 12, "A Look Ahead" calls attention to the importance of the rate of interest as a force operating to adjust the pace of investment to that of saving. Interest, however, is the only price discussed in this book. If the prices of commodities and services are neglected, it becomes difficult to refute the stagnationist view. Mr. Terborgh has therefore made his own task more difficult by accepting without protest the assumption made by some stagnationists and others that business volume can be discussed profitably without reference to the behavior of prices.

In the final section of the book (chapter 13) there is a sentence of exceptional significance. This sentence reads as follows: "There is a world of difference between the proper use of deficit financing, conjoined with policies calculated to minimize the need for it, and its improper use as a panacea." This sentence apparently reflects Mr. Terborgh's ideas of proper policy, and it certainly reflects the attitude of many economists who acknowledge the power of deficit spending and, in spite of this, disagree with the fiscal program of certain stagnationists.

APPRAISAL OF THE BOOK

Mr. Terborgh's chapter 6, "Dearth of Great New Industries," deserves special praise for its capable treatment of a difficult topic; and the entire book is worthy of attention; but some portions of it sound as if they had been written in too favorable an environment. Occasionally in academic circles a prospective author will find within his own department some men with opposing views. Criticisms by such men may then force him to make his argument ever more rigorous. A similarly critical climate may have been lacking in this instance; but under any conditions Mr. Terborgh's task would have been difficult. Investment is a tangible thing that can be measured; but Mr. Terborgh's problem was to measure investment opportunities, and these are intangible. Whether a specific opportunity is real or illusory cannot be determined by any census taker. Even if an opportunity is real, its magnitude is open to question. With respect to the total magnitude of all investment opportunities an inference is all that is possible. Mr. Terborgh does a good job in revealing the intangibility of the thing which both he and the stagnationists are attempting to measure. If he does not prove that in the absence of special obstacles such opportunities will normally be adequate in the postwar world, he does at least make one point: It does not follow, simply because certain specific sources of investment opportunities have disappeared, that total opportunities will necessarily be inadequate.

The existence of a need for a book of this kind is also worthy of note. Only a decade ago many Americans doubted the power of a federal deficit to enlarge the national income. When voters finally became convinced on this point, many of them—apparently without hesitation—jumped to the additional conclusion that such deficit spending was necessary as well as effective. Economists discriminate carefully between the power of deficit spending to create income and the stagnationist view that such spending will normally be necessary; but laymen in general have failed to recognize that the stagnationist view of future needs is regarded by economists as a hypothesis rather than as an established principle.

In the history of economics almost every novel idea has been followed by years of exploration and debate. The ideas that finally receive acceptance are frequently more complex and more carefully qualified than the original and perhaps rather simple ideas which start the controversy. The problem of the proper use of fiscal deficits is still in this preliminary stage of exploration and debate among economists. Mr. Terborgh's book does not close this debate, but many people will be glad that his book has been written.

Glued-Laminated Arches With Sawed Laminations

(Continued from page 819)

gluing pressures of from 100 to 200 psi, the usual practice for glued structural members, glue joints for sawed-face surfaces have 92½ per cent of the strength of glue joints for planed surfaces at 100 psi gluing pressure, and 90 per cent of the strength of glue joints for planed surfaces at 200 psi gluing pressure.

The use of well-sawed surfaces for glue joints therefore appears to reduce the strength of the joint not more than 10 per cent below maximum possible strength of the joint.

CONCLUSIONS

1 Well-sawed laminations for glue faces of glued-laminated structural members will produce joints of neat appearance and adequate strength if proper gluing and fabricating methods are used.

2 Machining of surfaces to be glued should be required only as necessary to obtain uniform thickness of each lamination or to remove any rough or torn grain.

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Canadian Engineers' CONTRIBUTION TO VICTORY

By GENERAL ANDREW G. L. McNAUGHTON

HONORARY MEMBER A.S.M.E., OTTAWA, CANADA

THIS is the first occasion on which I have had the privilege of being present at a meeting of The American Society of Mechanical Engineers and I welcome the opportunity to express my appreciation to the president and members of the Society for the very great distinction which they conferred on me in September, 1943, in admitting me to Honorary Membership.

I thank the Society most sincerely for this high honor which I assure you I do indeed value most deeply.

CANADA'S PART IN THE INCEPTION, DEVELOPMENT, AND PRODUCTION OF THE NEWER AND BETTER WEAPONS

I am to speak to you tonight about some aspects of science and engineering in the war and particularly with reference to the part taken by Canada in the inception, development, and production of the newer and better weapons and equipments with which to outmatch the enemy in battle and thus to give our troops in combat every possible advantage.

In the course of my remarks I will venture a few observations both on what is past and the difficulties and the dangers which were overcome or evaded, and on what I think the future probably holds; and I will endeavor to draw attention to certain vital matters which I think it is important that we should not again overlook.

It has been shown by experience that, granted time, we have the technical abilities and the physical resources to create the best of armaments. It has been shown, and proved conclusively, that we can have whatever we have the will and purpose to provide; and so it is in the realm of policy and direction that we have to be particularly careful.

It is understood, of course, that what I have to say represents my personal opinions only, for I have retired from the Canadian Army and, on the conclusion of active operations in the War, my resignation as Minister of National Defense in the Government of Canada has been accepted. The only official position which I hold at present is that of chairman of the Canadian Section of the Canada-U. S. Permanent Joint Board on Defense, which deals with the co-ordination of general defense matters between our two countries. These matters are, of course, outside the scope of my subject tonight, except that I would like to say to this representative body of engineers from the United States and from Canada, that I have a very deep sense of the importance of the work which has been entrusted to that Board to our mutual advantage as we go forward side by side into the future and face the great problems which will undoubtedly arise and which will require solution.

THE POSITION OF CANADA IN THE BRITISH COMMONWEALTH AND IN AMERICA, IN REGIONAL AND IN WORLD SECURITY

War is the continuation of national policy when peaceful means have broken down and so it follows that armament and national policy are very closely interlinked; in consequence, the requirements which condition the provision of arms are intimately dependent on the position of the nation in relation to others with which it may be associated.

Canada is a member of the British Commonwealth and she holds to that association with all the firm conviction which has marked the course of our history since early times. She holds to that association, not as any dependent Colony of a Central Authority in London, but as a nation in her own right, happy to co-operate in all matters which make for peace and orderly progress in the Commonwealth, and in the world; but with intention made clear to all that she will make her voice heard in deciding the objects of that co-operation, and that then she herself will determine the form and scale of the action she will take—that her decision in these matters, in so far as human judgment runs, will be based on the realities of the situation and the best interests of all concerned, her own included.

No one who has ever had close experience of the actual working of inter-commonwealth relations will question that all matters will be dealt with objectively by Canada or will doubt that worth-while causes will be supported; and that the effectiveness of this support, when given, will far transcend anything which might have been considered possible in the older outmoded imperial form of organization from which our present constitutional position has steadily evolved down the years.

But Canada is also a nation of the American continent and as a consequence we share many interests with you, interests which under modern conditions continue to develop with ever-increasing acceleration, particularly in matters of defense, where, with the remarkable progress in the application of science to war which we have witnessed during the last two decades, distance has lost its former attenuating effect on the problems of international relations. We must realize that continents have now become the geographical units in which most questions, both of peace and of war, must be stated and that effective arrangements for the defense of the territory of one nation has become a matter of vital concern to all other nations of that continent.

There are some who see a difficulty in reconciling our position as a nation on the American continent with our membership in the British Commonwealth, but I do not share this anxiety.

In the first place I believe that fundamentally the real interests of the member nations of the British Commonwealth are very close to those of the United States. In the second place I think we are a practical people ready to deal with each question as it arises on its merits and on the basis of the facts. We see no fundamental reason for conflict in interest, and you can be quite sure, with our deep concern for the welfare of each of these great associations of peoples with whom we are so intimately linked, we will devote ourselves on every occasion to promoting unanimity in view.

It is very satisfactory to note that in the steps taken at San Francisco toward world organization, provision has been made for developing security on a regional as well as, perhaps more remotely, on a world basis. Both are important and

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whatever we can do to promote the one will help also in the other.

THE SUPPLY SITUATION IN CANADA ON THE OUTBREAK OF WAR IN SEPTEMBER, 1939

In September, 1939, within a few days of the outbreak of hostilities in Europe, Canada declared war on Germany and associated herself with the United Kingdom in the struggle with the Nazis. Mobilization was ordered, and before Christmas we had an infantry division and other troops overseas in Britain. Apart from clothing and a few articles of a commercial type which could be used, we depended for equipment on the arsenals there, or on the reserves of armament which had been salvaged from the First World War; most of these were of obsolescent type.

It was not an enviable position as we soon confirmed that the supplies available in Britain were very meager to say the least; also there was little help to be obtained from Canada immediately, for in the interval between the wars we had completely demobilized the munitions industry which had been built up to considerable proportions in World War I.

We had in Canada plans for a rifle factory but it had not been built; we had a contract with a private concern for the manufacture of the Bren Light Automatic; we had a tiny arsenal capable of making small-arms ammunition and a few shells annually for practice.

Physically, this was about all; and anyone unfamiliar with our country and with its potentialities must have thought that we were very rash indeed to go to war and launch an expedition overseas.

But this was most certainly not all, for while in peace we had been denied the opportunity to develop our arsenals to any reasonable extent, nothing could prevent our thinking about the problem and making plans. We had been able to make a close survey of our manufacturing industries, and of our sources of supply for various materials needed.

This had shown that our industrial facilities were very widely diversified and highly efficient; that, given time, there was probably no article of war supply which we could not make in adequate amounts for our own purposes with something over for our Allies as well. We had the steel and the coal and the nonferrous metals and the light alloys which had become of very great importance; we had the nucleus at least of a machine-tool industry; we had potentially the labor and the trained mechanics and the engineers.

The problem was one of adaptation rather than of creation and so, granted decision and energy in execution, it could be solved within the time we thought might be available.

Moreover, this was not the unsupported opinion of our military officers alone, for in the summer of 1939 a group of our industrial leaders under the auspices of the Canadian Manufacturing Association had gone abroad and familiarized themselves with possible war requirements; these they were confident they could fulfill.

So also in the vital matter of the application of science to design and production for war the unique facilities of our National Research Council had been geared into our defence departments and were available to undertake the tasks required, with many of which the technical staffs were already at least partially familiar.

Further, as an added reason from which we could draw confidence, we had the factual record of the immense results achieved in the production of munitions in Canada during the First World War once the dead hand of absentee control had been suppressed and the initiative of our manufacturers had had some freedom to express itself.

It is true that our production then had been primarily confined to the simple types of gun ammunition, training aircraft, and the like, and that we had been content to take the designs and specifications which had been given to us from England; but a study of the history of this effort had shown up some very significant facts which were most encouraging for the future.

In the first place, it was clear that the application—even to the limited extent permitted—of the North American technique of mass production had increased the rates of output manyfold over what had been expected under the methods of British industry then current; the costs as measured in money or in man-hours had been decreased very remarkably.

In the second place, in the most important matter of quality the record had been superb; and further in the later years when the industry had got well under way there was clear evidence that our engineers had not rested content with the routine of production but had shown initiative and inventive capacity of a very high order.

Before the First Division sailed from Canada contracts had been placed for all the motor transport required; designs and prototypes were available. Here, in this city of Detroit which is so closely associated with our own motor industry, I wish to pay my tribute to what was accomplished. By the early spring of 1940, when we were due to cross from England into Europe to join the British Expeditionary Force under Lord Gort's command, the many thousands of vehicles required had been delivered to us overseas, mostly from our own plants in Canada; and, going on from there, throughout the War we received in an unending stream new designs quickly evolved to meet new needs as they became apparent.

I say to the men of the Canadian motor industry, and to you here who have helped us so much, that this early performance was most heartening and encouraging—it was right up to expectations, not only in the quantities delivered, but even more important in the excellence of the product.

I wish I could say the same for other matters of supply, but in most things, before these could be arranged, those in authority overseas seem to have got the idea of a "phony war" and there was delay and apathy in placing orders which was not broken until the rude shock of the fall of France brought everyone to their senses and to a realization of the dire peril in which we stood. Then Canada really did get going.

THE PERIOD OF IMPROVISATION IN BRITAIN FOR DEFENSE

Overseas, meanwhile, we had managed to get the First Division fairly well equipped but with the greatest difficulty and we certainly had enough experience with obsolete and unsatisfactory armament to rub in the lesson of the need of new and more appropriate designs; but in the imperative necessity to give all attention to organization and to training there was little that we could do to improve matters at that time.

In the battle of France we had one essay across the Channel when we were sent to support an army which did not exist except in the imagination of a crumbling government and then we had to withdraw with more haste than dignity.

In the retreat from the continent of Europe the British Forces had lost most of their equipment, armament, munitions, and reserves and there was very little available in the United Kingdom for the reason that during the "phony war" most things had been sent forward as they were made to depots in France and these had been overrun before they could be moved.

In the Battle of Britain, even in rifles we were to begin with tens of thousands short for the actual numbers of men in the units. So perforce we were driven to improvisation.

There were few antitank guns so we had to imitate David, but the missiles to be thrown were not "the smooth stones out of a brook" with which he had disposed of Goliath, but bottles of phosphorus and naphtha which burst into hot flame spontaneously on impact. I recall the great search made through the ancient manuscripts in the Bodleian Library at Oxford to ascertain the exact composition of Greek fire which had last

been used decisively in 1100 when Alexius of Constantinople routed a Pisan fleet by its use.

There were few antiaircraft guns, so antiaircraft mountings had to be improvised for light and medium machine guns and for field guns; and so on throughout the whole range of requirements.

We did not possess the modern weapons needed so something else had to be found to take their places. Explosive obstacles to surprise and destroy enemy tanks, trip-wires to wreck enemy planes and gliders attempting to land on any areas where this form of attack was thought likely—the whole business was very primitive indeed.

Even guns which dated back to the era preceding the South African War which had been placed in store by the thrifty Admiralty were taken out and pressed into use mounted on commercial vehicles of sorts with boiler plates for armor. They may not have been very effective but in their utter ugliness they looked formidable and that was something.

With great truth, through the long days of the summer of 1940, Britain was held largely by bluff, for it is difficult to believe that any serious attack from across the Channel could have been effectively resisted.

I have mentioned these experiences to give point to the lesson that no nation can ever afford to neglect its armament. By being deluded into this path after World War I the Allies very nearly lost the last opportunity to redress the balance in Europe and so begin the series of great campaigns which finally brought us to victory. Certainly no Canadian who was there will ever forget this experience, and I hope that the lesson will be well remembered by those who now have the duty to show prevision and who have the power to act.

THE PERIOD OF PREPARATION FOR THE RENEWED OFFENSIVE ON THE CONTINENT OF EUROPE

All through the summer of 1940 reinforcements came to us from Canada across the wide spaces of the North Atlantic as fast as ships could be found to transport the men and move their supplies. By the autumn the forces in the United Kingdom had grown to considerable dimensions and both British industry, and our own, with your good help, were making the most strenuous efforts to correct the deficiencies in equipment and armament. By the early winter we could feel that Britain was a bridgehead over against the Continent of Europe, reasonably secure, in which the vast potential forces of North America could be assembled in due course and we had faith that in proper time and season our sister nations on this Continent would join us in the struggle.

We could lift our eyes from the immediate pressing problems of defense and contemplate again the time when we might strike back in Europe itself—when we could meet the enemy there again in open battle to seek a decision which would bring about his final defeat.

We could lift our eyes and give our thoughts to the plans and preparations that needed to be made. We could think out what we should do in order to make the best use of all the great abundant advantages which we had—or could have if we had the wit to turn them to account.

And what are these great inherent advantages for the making of modern war which are characteristic of the North American continent—both of Canada and of the United States?

Our young men are highly educated and naturally familiar with mechanism in all its varied forms—intelligent, resourceful, full of initiative, and responsive to leadership.

Great home countries in active process of bringing their vast natural resources into use and engineers skilled in the art and accustomed to the conduct of projects of the greatest magnitude.

Mass-production industries of great variety, and most comprehensive, which can take a new design and rapidly turn it out in any numbers needed and with the high precision which is required in the weapons and apparatus of modern war.

Industrial leaders of vision and resource trained in the hard school of a developing economy; raw materials in abundance; wide experience in engineering, and in research, and in developments of many kinds.

What we needed for the European attack was the most highly mechanized army which could be created, equipped, and trained in the limited time available before this great endeavor could be launched. Certainly in 1941 we had at least two years; quite possibly more.

We needed armor and engines for employment in the field. We needed new and better mechanical vehicles to give us facility for rapid movement and to transport great masses of equipment over great distances. We needed new and better weapons of greater power and range and more precision in the accuracy with which they could be directed on the vital points within the enemy's dispositions. We needed new and better propellants for our guns. We needed new explosives of more intense character to shatter the enemy's fixed defenses of concrete and steel and to penetrate the heavy armor of his tanks and other fighting vehicles. We needed better cameras and optical equipment to detect and locate his works for defense and offense and overcome his camouflage. We needed better gear to track his aircraft and bring effective gunfire against them in the few split seconds that they might be engaged.

We needed means to create new airfields with the utmost rapidity close up behind our advancing armies so that they could continue to enjoy that intimate air support which had become essential. We needed docks and wharves to turn an open beach into a port, and bridges to cross the many large rivers that lay across the path of invasion into Germany. We needed amphibious vehicles to facilitate the landing and the negotiation of streams and swamps and other water obstacles. We needed to experiment ceaselessly with all this new gear to work out and evolve the form of organization and the methods which could best be used.

We could spend material in the most generous profusion to bring about the enemy's defeat and it was right to do so to save the precious lives entrusted to our care.

Much of this great work of experiment and development had gone on in the Canadian Army as opportunities were made throughout the period of the Battle of Britain. There had been the closest co-operation with the various British authorities and with their encouragement progress of considerable value had been achieved in many lines which we had undertaken as our share in the general effort.

For the supply of the vast assortment of the material required we had to look principally to North America. The factories of Britain were under air attack and subject to serious interruption.

Available labor was scarce and urgently needed for maintenance and other purposes and, most important, we had learned from hard experience that designs worked out in the British industrial environment were often unsuitable for mass production according to the North American technique. Screw threads differed; rivets spaced for insertion by hand could not be placed with our automatic machines; and we literally could not do in quantity the elaborate hand-fitting which was the customary practice in the British Isles. Even technical terms had different meanings on either side of the Atlantic and some there were who were opposed to new devices for they threatened the supremacy of established interests.

It was necessary, therefore, if unfortunate delays were to be avoided, as they had to be, that detailed designs should be developed at home and that those who were overseas should content themselves with giving the general idea of what was wanted, together with the most complete "user specifications" that they could define.

By early 1942 we were in the closest touch in the United Kingdom with representatives of the American Army and the

results of all our trials and experiments were given to them without reserve. In return we had their welcome collaboration and their valued advice and help.

In Canada the need for newer and better weapons had also been recognized; an organization for development had been established and great efforts were being made to translate our requests into models with which we could experiment; and here too the closest touch had been established with the United States Army and with United States industry so that all facilities might be developed for the common purpose without duplication or waste of priceless time and effort.

In the tank, for example, our engineers in Canada took the M.3 and from it evolved the Ram, which in its turn contributed to the M.4, the Sherman, the tank which we used with every satisfaction in operations from 1943 onward. We had well-founded confidence in it, for we knew that it incorporated the features to which we attached special importance and we had had the opportunity to test and comment on its performance from the days of the earliest models.

As another example of the close association between Canada and the United States which came about, I mention radar. Our National Research Council had been early in the field with the C.R.D.F. and some purely scientific investigations on the height of the Heaviside layers and this gave the background for immediate progress when early in 1938 the suggestion came from England of the vital importance of tracking enemy aircraft while yet they were at great distances so as to have early warning of attack.

As a result we were able during 1941 to develop a design of reasonable performance and in 1942 we had the great satisfaction of turning over a considerable number of these sets to the United States Army for their use at a time when the requirement was very critical. I can assure you we were very happy indeed to make this contribution in what was then a very new and novel art.

The radio fuse is another example of the flexibility and co-operation between our two countries which came into being. The first developments in Canada were started at the University of Toronto in 1940 and the early activities of our two countries were closely co-ordinated later as it became evident that the special and extensive facilities required for rapid progress were to be found only in the United States. The Canadian effort was restricted to a few special phases of the problem and the Canadian scientists who had been working on it came under American direction.

In the mechanization of flame warfare, in new methods to smash armor, in new ways to pass through mine fields, and in countless other matters of great import the story is the same.

A case of special merit is exemplified in the organization for the study of chemical warfare and of the other similar methods to compel an enemy to comply with our will. The Canadian and the United States laboratories were hardly distinguishable from one another and the staffs from one country moved without restriction in the establishments of the other, and common use was made of all the testing grounds and other facilities wherever located.

I have mentioned these few examples from among the many to show the close integration which had been achieved in the development of war equipment. In the result, and thanks to mass production and the most careful standardization, our armies were given in full supply the best that could be devised of everything required.

For the invasion of Europe they were the most perfectly equipped of any armies which had ever gone to war. They had attained the highest standard in the application of mechanism to ease the task and multiply the power and speed and range of man, to conserve life, and to aid and facilitate the completion of the tasks which had been entrusted to them.

LEND-LEASE AND MUTUAL AID

Not the least of the matters of importance in connection with the arrangements for the equipment and maintenance of the armies, both yours and ours, has been the method by which the financial costs, running into astronomic figures, have been met.

We each have had the problems not only of paying for *everything* which our own armies required across the whole range of costs from guns and aircraft to clothing, food, and medical supplies, but we also have had the problem of providing for the costs of what we placed in the hands of Allies for their armies, and for their civil populations as well, so that they might be enabled to do their part without the accumulation of continued debts which could not be liquidated and which would embarrass both them and us in the period of postwar reconstruction.

You solved this problem by "Lend-Lease" and we by the similar procedure of "Mutual Aid." It is a source of great satisfaction that Canada's effort in these matters has been entirely self-financed. We accepted no monetary aid from anyone, and on our part we saw to it that no burden of debt was placed on those we sought to help.

The measure of this help, which we were glad to give and bear, runs to amounts expressed in thousands of millions of dollars—amounts which have been, or will be, met by the thrift and savings of the Canadian people both during the war and in the period which now follows.

And so at last we come to victory, decisive, all-embracing, and complete, and in this long-sought result the scientists and engineers of both our countries and from Britain across the sea—the men responsible for design and production—can take the greatest satisfaction in the contribution which they have made. We started with very little and in a position far inferior to our enemies. We quickly overtook and then surpassed them, not only in the equipment actually in use, but in every new line which they had visioned into the future.

As one who watched these matters with close attention, and very anxious interest, throughout the war, I express my sincerest admiration at the achievement.

CONCLUSION

The note on which I wish to end is not one of complacent content for in the world today we cannot afford to rest. We have gained victory, but it is yet to be confirmed through the organization of security and of the will to use force, if needs be, to maintain peace. It is a vital requirement that the Allied Nations who think with us remain collectively the strongest military force on earth, and each and every one of us must make our contribution to this end.

We have entered, and are far along, into the period of the application of science to war and the rate of acceleration makes the arms of today of lessened value for tomorrow. Already we have the atomic bomb, a decisive weapon in this year and day of grace, but it as well represents nothing more than a transient advantage unless we maintain our lead; for the means to counter are already clearly in sight.

If we are to retain our place as the Wardens of Peace the most important thing we have to do is to maintain our research and development and to continue to produce the newer and the better weapons, at least in prototype, and ceaselessly to experiment to master the technique of their employment.

In this great task I earnestly hope that Canada and the United States will long continue the satisfactory and fruitful collaboration which they have achieved in these matters.

Developing CREATIVE ENGINEERS

By J. F. YOUNG

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To stimulate the development of creative inventive ability in young engineers and to promote application of this ability in engineering, the General Electric Company eight years ago established its "Creative Engineering Program" as a partner to its well-known Advanced Course in Engineering. This paper reviews the progress made in understanding the rare talent of ingenuity and also describes the selection of candidates, the training given, and the value of the program as indicated by the work of its "graduates."

FOR many years, industry has recognized the importance of creative inventive engineering to continued progress and, accordingly, has accepted responsibility for the development of creative ability in young engineers. Usually, this has taken the form of the time-proved method of apprenticeship. Young men who show signs of creative talent are associated with senior engineers who can in some measure nurture its development and provide inspiration and guidance.

But even though management is ever on the lookout for men possessing this ability, their discovery in the past has for the most part been happenstance. It has usually been necessary for the creative spark to assert itself under conditions which did not encourage creative work or give opportunity for its practice. Sometimes, regular assignments have catalogued a man according to type, e.g., research, analytical, or production, and the assumption of responsibility for a major project requiring broad creative ability and practical design sense might not be entrusted to him. Under these circumstances, only exceptional men gained recognition for creative genius, and the intuitive abilities of countless engineers have been lost to industry and to society.

PROGRAM ORGANIZED

In the interest of establishing a more purposeful plan for discovering and developing these abilities, particularly in young engineers, the author's company, in 1937, organized its "Creative Engineering Program," under the able direction of Dr. A. R. Stevenson, Jr., director and cofounder of the company's already famous Advanced Course in Engineering.[1] This paper outlines some of the factors associated with a creative approach to engineering problems and shows how these factors apply to the selection of personnel and to the training given in the new program.

When the program was begun, creative capacity was initially interpreted as facility in the art of design,[2] that is, the emphasis was placed on ingenuity for selecting materials and functional-design forms and adapting them to manufacturing processes. This type of activity is within the field of mechanical engineering, so only mechanical graduates interested in design work were selected for the first classes. For an industry which manufactures many electrical products, such a procedure might, at first, seem restrictive. But, design or production of even electrical products like induction motors or radios involves from 70 to 80 per cent mechanical engineering, and it therefore seemed reasonable to start with this phase alone.

It soon became clear that emphasis on the art of design was adequate for "reduction-to-practice" engineering but overlooked the imaginative creative engineering that goes into the choice of the fundamental design plan. The guiding objective was therefore enlarged at the end of the second year to interpret creative engineering in a broader sense as comprising the entire chain of efforts leading from the conception of a device to its delivery to the customer. This meant that invention in the elements of a device or its final form was an essential but component part of the creative process. It also meant engineers with electrical or electronic interests, among others, should participate. The program is still organized on this basis.

Men possessing the talent sought were not easily selected at the outset. Upon contacting college professors concerning students who might have the proper aptitudes, the answer was usually the same, "We do not know. There is nothing in the college curriculum to show us." This condition is slowly being altered and a greater emphasis placed on the artistic creative side of engineering in the colleges and universities as a result of encouragement by industry and the engineering societies, particularly the A.S.M.E through its Committee on Education for the Industries.[3]

THE TECHNIQUE OF SYNTHESIS

The failure of formal study to bring out creative talent is probably best explained by the contrast between the method of analysis which underlies scientific training and the method of synthesis employed in the intuitive process of invention. The analytical method is habitual, logical, step-by-step. It involves critical separation of each element of a system and discovery of interrelationships. Through this method, as applied to design, optimum refinement and improvement are often accomplished, but, strictly speaking, nothing is created. The results of analysis may, however, establish the requirements leading to invention. For example, calculations on ballistics may suggest requirements for a bomb sight or a gun director; but a new choice of elements to perform such a function or an idea of some new function is an act of synthesis apart from the analysis. In accomplishing the act of synthesis, it is necessary to obtain an approach to the problem that is not habitual from the standpoint of current practice. New, unprecedented association or combination of similar, contrasting, or succeeding elements is arrived at. The form of product undergoes development and functional arrangement rather than introspection. In these respects, synthesis is not acquired by scientific training but must survive this training and instinctively apply its technique.

Normally, there can be no constructive synthesis without a proper understanding of the underlying fundamentals. In any creative endeavor, analysis and synthesis must go along together, supporting each other. When one man does not possess these abilities in the measure required, the complementary talent, together with the others[4] usually needed are provided by teamwork.

Experience with young engineers doing creative work indicates that the process of synthesis is essentially individualistic. The techniques used differ considerably and thus are not amenable to "teaching." Perhaps this is a further reason that

[1] "An Advanced Course in Engineering," by A. R. Stevenson, Jr., and Alan Howard, *Electrical Engineering*, vol. 54, 1935, pp. 265–266.

[2] "Encouraging Creative Ability," by A. R. Stevenson, Jr., and J. E. Ryan, MECHANICAL ENGINEERING, vol. 62, 1940, pp. 673–674.

[3] "Creative Engineering," A.S.M.E. July, 1944.

[4] "How Collective Genius Contributes to Industrial Progress," by K. K. Paluev, *General Electric Review*, vol. 44, 1941, pp. 254–261, points out that some 15 basic faculties are important to the creative process. Later analysis indicates these may be further subdivided into 36 elements, 2 physical, 4 intelligence, 7 accomplishment and imagination, and 23 personality and temperament.

creative ability does not flourish under formal study. Within the techniques of synthesis observed, however, there appear to be four[5] common stages. In so far as recognition of these stages can make the young engineer aware and confident of the progress of his creative effort, they are presented as an acceptable structure for promoting the application of these abilities to engineering problems.

1 *Definition of the Problem.* Before any suitable action can be taken, the problem must be found and formulated. It is highly important that the problem be defined exactly, and sometimes data must be gathered for this purpose. Most people are not inventive because they do not take this step, or because they become discouraged with initial failures; others because they define the problem erroneously. Inexact definition may result from influence of the past art (that is, not getting a nonhabitual approach), or from insufficient understanding of the fundamentals involved. The result in either case is solution of the wrong problem. For example, the first alternating-current contactors for breaking a resistance load current opened as fast as possible because this had been found necessary for earlier designs of direct-current contactors. Actually, less contact burning is obtained by breaking this type of load slowly and extinguishing the small arc as the alternating-current voltage goes through zero, rather than by fast opening, which draws a large hot arc, and depending on extinguishing the arc by air-cooling.

2 *Manipulation of Elements Bearing on Solution.* In this stage, individual characteristics are more evident. One prolific inventor believes there are "eight ways of doing everything" and insists on finding most or all of them before making a final selection. He frequently pages through an old book of inventions, not to copy, but to stimulate formation of mental images and association of basic elements. Another keeps a scrapbook of his previous ideas and leafs through it for the same purpose. More frequently, engineers "search for power," that is, they try various types of motivation or sensitivity such as electric, hydraulic, chemical, mechanical, and electronic means. Various forms are tried for fit, like pieces of a jigsaw puzzle. For some problems, this stage may involve a great amount of work and usually is nearest completion when the situation seems the most hopeless.

3 *Period Resulting in the Intuitive Idea.* It is the act of invention—the patent docket stage. Most often, the "flash of insight," as it is called by Prof. E. D. Smith,[6] comes during a period of relaxation or activity not associated with the problem. New ideas often occur at meals, when traveling, or while attending a social event. One inventor gets many ideas during dreams and keeps a drawing board near his bedroom to record the ideas before they are lost. This occurrence of ideas independent of direct activity on the problem appears associated with some characteristic similar to a subconscious mind. After outward activity of stage (2), the problem is continuously manipulated with elements of experience and knowledge until a solution suddenly emerges.

Occasionally, the idea will occur spontaneously as the result of a new experience. K. K. Paluev[7] likens this to a customer seeking some unknown article. He doesn't know what the article should look like although he does know what it must do. When the appropriate article is seen, it is suddenly recognized as capable of performing the necessary service. In other words, the inventor mentally stores well-formulated problems, and the instantaneous association of the requirements with a new experience leads to the act of invention.

There is still another conception of this stage. It is what Dr. W. R. Whitney[8] calls "hunch," that is, the intuitive use of some scientific data or laws before they are known. Hunch may also take the form of a stab or trial at solution. Some individuals, on being confronted with a problem, immediately think of an answer. Later mental activity often shows the hunch unable to satisfy the particular problem, but continued activity makes possible many successes.

Although various authorities describe the act of invention differently and find the individual steps involved difficult to analyze, they do agree that the speed of thought is very high, and that facility in this stage is dependent on calling upon previous knowledge and experience. The greater the accuracy and completeness with which knowledge and experience are stored, the greater the potential inventive capacity. In this respect, the substantial progress in creative work made through engineering conferences appears due to great collective knowledge and experience and the stimulation this provides each individual participating.

4 *The Idea Is Shaped to Practical Usefulness.* Each element must be defined in a form that can be suitably manufactured, and the form must be proportioned in proper relation to the anticipated service. Calculations or model experiments may be required to determine the relations necessary. Sometimes all the work can be done by one engineer, but in any major development the collective action of an engineering organization is employed to take advantage of special skills and to reduce completion time.

Great perseverance and optimism are required in this stage to see the job through, to inspire others, to maintain their confidence, and to persist in the face of discouragement, such as errors, trial failures, and criticism. This is the 99 per cent of Edison's famous statement that inventions are 1 per cent inspiration and 99 per cent perspiration.

SELECTION OF ENGINEERS FOR CREATIVE WORK

It is generally agreed that some of the aptitudes which have an important influence upon inventiveness are hereditary, but that the majority of aptitudes necessary are subject to development under proper environmental circumstances. Naturally it was in this light that the Creative Engineering Program was founded and, in the experience to date, there has been no evidence to the contrary. Actually, it has been found that most all good engineers possess a creative spark in some measure, and it has been possible to develop it to a greater extent than at first expected. This talent does not develop naturally in spite of surroundings, however, and it has been difficult, therefore, to recognize and evaluate in young engineers with different backgounds and of various degrees of maturity.

Some evidences of creative capacity are found in hobbies. The model-airplane builder for instance may tire of making models according to the existing designs, and proceed on his own to a new type, discovering the operating relations among the parts as he goes. Engineers brought up on the farm may also have had somewhat similar experiences in the repair or construction of farm machinery. These are good signs and are

[5] "A Technique for Producing Ideas," by J. W. Young, Advertising Publications, Inc., Chicago, Ill., 1944, cites five basic steps in producing ideas in advertising. They are: (1) gather raw materials, (2) mentally work over these materials, (3) the incubating stage where something besides the conscious mind does the synthesis, (4) the birth of the idea, and (5) final shaping and development. Prof. E. D. Smith in "Some Psychological Factors Favoring Industrial Inventiveness," MECHANICAL ENGINEERING, vol. 66, 1944, pp. 159–162, points out three steps: (1) period actively engaged in problem, (2) period not actively engaged on it but on something else, (3) period after solution working out details. Prof. E. D. Hutchinson in "Psychiatry," vol. 2, August, 1939, pp 323–332, points out four stages in solving a creative problem. They are: (1) a period of preparation, (2) a period of renunciation or recession, (3) a period of insight, and (4) a period of verification, elaboration, or evaluation.

[6] "Some Psychological Factors Favoring Industrial Inventiveness," by E. D. Smith, MECHANICAL ENGINEERING, vol. 66, 1944, pp. 159–162.

[7] "How Collective Genius Contributes to Industrial Progress," by K. K. Paluev, *General Electric Review*, vol. 44, 1941, pp. 254–261.

[8] "Things I Have Been Thinking About," by Dr. W. R. Whitney, *American Magazine*, Oct., 1937; "Creative Engineering, Inventiveness, and Intuition," by Igor Sikorsky; pamphlet on Creative Engineering, A.S.M.E., July, 1944, pp. 3–6, also uses this conception.

easily recognized. Once in a while an endeavor of this type has led to an actual patent or a scrapbook of "ideas" which is even better evidence.

When the opportunity for hobbies has not arisen, as for many engineers who grew up in large cities, signs of creative capacity may be indicated by study of the characteristics associated with the afore-mentioned technique of synthesis. Perhaps of most importance is the knowledge pattern and quotient. By this is meant the knowledge and experience applicable to the technique of synthesis and the degree to which they are present. There are three important parts to the knowledge pattern as regards creative work, (1) scientific knowledge, (2) design curiosity, and (3) the ability to generalize experience. The first, as mentioned earlier, underlies all engineering, and without it little engineering contribution can be expected. The term "design curiosity" refers to interest in engineering works, how they operate, and how they are constructed. This interest provides a means for developing a sense of proportion[9] and a feeling for design strength, size, and power. The last, the ability to generalize experience, refers to the facility of storing information mentally and in a pattern that can be easily and accurately recreated and applied. Special reference to the act of invention is implied here.

In evaluating these three phases of the applicant's knowledge, it is recognized that the actual knowledge already acquired can be enhanced by further training; but the degree to which an experience is retained and the pattern of retention are not as easily trained, if at all, and are therefore significant.

It was mentioned previously that the characteristics of perseverance and optimism are also necessary in order to see a problem through to a finish in spite of difficulty and disappointment. Another important factor is constructive discontent. No matter how good his tools, an engineer will not create unless he possesses discontent with things as they are, either in themselves or their limitations, and has the desire to improve them.

Still another factor is the habit of using intuition in the solution of design problems. This habit involves strong imagination and a speculative and alert nature. The individual must be willing to take a chance or "stick his neck out." He thus develops the intensity of interest required to rise above the average and places faith in himself and his idea so it is seen through to a conclusion. Alertness is important for it assures awareness to the coming of an idea.

Not all inventions, as mentioned before, are the result of direct activity, but often an observed experience provides, through association, an answer to a different problem, that is, the invention is a by-product and opens up some new endeavor. Research inventions are often of this type. Alertness is also important because not every idea is the right one. By being alert to their coming and by using all measures that can be commanded for checking them, the right one can be singled out.

Besides these rather special characteristics, a number of general characteristics of importance to any engineering activity should be given consideration. Some of these are intelligence, business or engineering sense, energy and willingness to work, leadership, personality, and the ability to get along with others. To some extent, leadership, personality, and ability to work with and through others need not be present in the same degree for a highly inventive person as for others. However, in industry, very few individuals can be lone workers, and the man who possesses these abilities as well as creative ability can accomplish infinitely more.

DEVELOPING METHODS OF SELECTING CANDIDATES

The number of talents cited makes a rather impressive list and yet each is important in the part it plays. First attempts to select engineers possessing the right balance of these abilities were only moderately successful. A mechanical-aptitude test intended for the college level was tried with both gratifying and disappointing results. All the applicants rated in the upper 5 per cent of all persons tested, but there was no correlation between test ratings and abilities observed during a 2-year period. It seemed that as much intuition might be required to select creative engineers as they were to possess. Over a period of a few years, however, a highly effective plan of personal interviews was developed. Instead of a single short interview with one person, interviews lasting an hour or more were arranged for applicants with a number of older engineers who had daily experience with the training of young creative engineers. These interviewers met frequently to discuss candidates and the progress of those selected. In that way they very soon were able to recognize signs of creative capacity, whether they could be defined in words or not.

In conjunction with this method of selection, other measures were tried, primarily as experiments to obtain a better measure of the talent itself. Even analysis of handwriting was considered. Samples of copy work and original work were obtained, but their analysis although positive in more than half the cases was often found to be entirely incorrect. Certain types of puzzles and short problems having engineering importance were also tried but these too were not found to be reliable enough. Some potentialities seem to be indicated in examinations which (1) measure knowledge of the fundamentals of physics in a nonanalytical way, (2) test design curiosity through test of observation, and (3) judge ability to generalize experience and recreate it by providing an experience new to all applicants, and by attesting their ability to apply it to several associated fields. Further exploration is needed to ascertain the effectiveness of this approach.

PRESENT PROGRAM

Each year approximately 30 young engineers are selected for the program on a competitive basis. The interview method is used, taking into account the factors just discussed and recognizing that facility in the exercise of most of these factors can be developed with practice. A few engineers come to the program directly from the colleges, but the majority are chosen from those having completed a year or more of experience in the company's testing department. There are two important reasons for this: (1) The experience and contacts obtained in this work become of great value to these men in their engineering activities. (2) Test training also provides an opportunity for some of the creative instinct to assert itself and in that way aids selection. For interested candidates whose backgrounds show little evidence of creative ability, special trial-test assignments in the design of new testing equipment are arranged and very often these assignments bring out unsuspected talent.

The principal part of the training provided consists of an organized series of assignments on contributing engineering work under the direction of senior engineers acknowledged to possess intuitive creative ability. In the course of a year or longer, each young engineer works on four or five assignments in turn. The engineer to whom he is assigned supervises his work and takes special care to develop stability and unity through discussion and personal example. In so far as possible, the young engineer is given complete responsibility for the design of a device so he may gain the experience and confidence essential to a productive career.

This follows the method of apprenticeship mentioned earlier but has several important differences. The frequency of assignments makes it possible to have each man work on several different products and in several different fields, and thus assures an opportunity for a "nonhabitual approach." Assignments also vary from pure development to production-design engineering and, where possible, are graded in responsibility and guidance so the engineer comes to depend upon himself as

[9] "How Useful Is Your Sense of Proportion," W. E. Johnson, MECHANICAL ENGINEERING, vol. 60, 1938, pp. 481–484.

he gains experience in the program. Perhaps even more significant is the supervision of several different senior engineers. Much as an artist is developed by association with a master, so the creative engineer develops in his work with the senior engineer. But work with a number of these men allows the trainee to gain inspiration and technique from all, without the liability of losing his individuality in the tendency to emulate any one of them.

Those selected spend a half day a week in class on company time during 35 weeks of the assignment period. Although the first classes were established somewhat as an afterthought, classroom work is now considered a valuable asset to accomplishing the most through the assignments. The classroom develops an *ésprit de corps* that is of immense value in the conduct of assignment work and also provides a means for "sharpening" the engineers "tools" and for emphasizing the objectives to be attained.

Classes are supervised by young graduates who devote most of their time to the work. This provides an excellent opportunity to develop qualities of leadership in the few who can be given this privilege and assures a close relationship with the needs and ambitions of the classes. Whatever time the supervisor has to spare is spent on engineering problems in a junior consulting capacity.

The classwork is quite varied. Considerable emphasis is placed upon understanding the fundamentals of physics which underlie engineering. Subjects covered include dynamics, elasticity, thermodynamics, heat transfer, hydrodynamics, electric circuits, electric machinery, and basic electronics. Lectures on these topics are given by a large number of older engineers from many departments. Recently, a new method of presentation has been tried. Instead of following the classical analytical case method, some lectures were presented from a more general viewpoint, attempting to outline a whole field and stressing the "physical picture," the various methods of attack, and the applications. It appears that creative engineers are more interested and absorb more with this approach and it seems to promote their facility for generalizing experience.

Home problems requiring 6 to 10 hours are assigned each week. Approximately half of these are chosen to get the most out of the study of fundamentals. The other half deals with design questions of interest to the company's engineering departments. New live problems of this type stimulate creative thinking and the "nonhabitual approach," and help each young engineer develop a technique of synthesis suited to his gait. Solutions to these design problems are often of use to the department concerned.

Problem solutions are written up as engineering reports to develop proficiency in presenting engineering studies. These reports are constructively criticized for technical excellence, originality, and presentation. Numerical grades are usually assigned, but grading of some design problems is difficult because a successful idea cannot always be developed in a week's effort. Longer problem assignments and overlapping assignments help make it possible to get answers to every problem assigned and, in that way, give the engineers confidence in approaching any new problem. Sometimes solutions are evaluated in class seminars led by a representative from the interested department. Such discussions enable the young engineer to see the problems from different aspects and in the light of different practice and principles.

A good portion of the class time is spent in inspection of manufacturing departments. These trips are augmented by talks by shopmen for answering questions and bringing out important points. In this way the young engineers' knowledge of materials and factory processes is furthered. Other subjects covered in the classroom period include informative talks on various phases of engineering, company policy, and patent law, training in freehand sketching which is a valuable tool in design work, and review of design progress in given lines of activity through study of developmental models and examples of the application of new ideas.

During one month of the classes, each man works on one or more inventive design projects of his own selection as part of the homework. Those who wish to construct working samples of their design in their spare time have at their disposal a well-equipped machine shop in a local technical high school. These projects are good indicators of the direction as well as the magnitude of a man's ability.

A short evening course in the "engineering approach to human relations" is also conducted. This course is an indication that technical skill or inventiveness alone is not enough—a young engineer must sell his ideas and himself in order to secure co-operation and results with those with whom he works.

RESULTS ACHIEVED

In the 8 years the program has been operated, a total of 133 men have graduated from it. One hundred and ten or 83 per cent are still with the company, eleven having gone into the Armed Forces and the others having left the company voluntarily.

The graduates have been of two types. A small proportion have possessed a very high degree of inventiveness and have been interested only in developmental phases of engineering. They thrive on new problems but have little interest in carrying through to a finished product once the method of accomplishing the result is known and proved. A second majority type follows the objective of the program more closely. They are design engineers who apply ingenuity at the proper stages of the design problem but who get immense satisfaction from carrying the work through to a finished product ready for delivery to the customer.

In both groups there have been many examples of broad individual achievement considering the comparatively short experience of the graduates. Most of them have several patent dockets by the time their rotating assignments are finished and continue in this direction on their more permanent assignments which follow. The percentage of dockets which are carried through to patents is not obtainable at present because so much of the work has been on projects of military importance. The contributions made and the responsibilities assumed during the war have, however, been large. In all probability many of the developments sponsored could not have been undertaken without this pool of creative engineers from which to establish and expand engineering forces. Large percentages of the graduates worked on radar, gun computers and directors, superchargers, and jet propulsion.

The program, it is believed, has definitely proved itself through the many important contributions of its graduates. Naturally, like most training programs, it has been possible only to provide an introduction to the field of creative engineering. Each man has received encouragement to do this type of work, has gained some practice in it, and has in some measure "glimpsed the horizon." Except for departmental supervision and stimulation, he is left on his own to continue his study and development as he rises in professional stature. It is felt that the full potentialities have not yet been realized because of the period of years required for full expression of the talent. Ultimate expectations depend on further progress in understanding the abilities sought and in providing encouragement and development of these abilities earlier in the educational system.

The program was curtailed in 1944, because of the scarcity of engineering talent for direct production of war products. Classes have already been resumed, and there is every indication that they will prove equally as valuable in reconversion and the peacetime economy to follow as they have during the war.

LETTERS APPLYING *for a* JOB

What Can You Do To Make Them Get Results?

By ELLIOTT DUNLAP SMITH

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A GOOD letter of application is often the key to a favorable interview and a good job. The first step in getting ready to write such a letter is to look at the problem from the angle of the employer who has a job to offer.

HOW THE EMPLOYER READS YOUR LETTER

These are busy times for him. When he comes in in the morning, he is likely to find a pile of letters of application on his desk. As he glances them over he picks out the ones that look sufficiently carefully written and attractive to be worth keeping to read. Some that look bad enough he may drop in the basket unread. The letters he has kept he reads through, watching the general impression that each letter gives as to whether the writer will make good. He notes the main facts about the man's record, but he notes especially what the manner in which the letter is written tells about his fitness for the job.

If the letter, on this first reading, convinces the employer that the applicant is worth further consideration, he reads the letter again but in a different way. He goes over it line by line, trying to discover what each line shows about the man who wrote the letter. At each step he looks at the facts alleged, but he looks much more at what the letter itself shows. Nothing escapes his attention. Does the writer in giving his record state the important facts and omit the unimportant? Does he give the employer a chance to check up on him by giving references? Do the writing, the spelling, and the wording of each sentence show a writer who really wants the job enough to take exceptional pains to get it? What does each sentence show about the writer's force, resourcefulness, and common sense? And so on, line by line, until he has wrung from the letter everything it can tell him about how far the writer possesses the general and special qualities which are important for success in the position in question.

It is important to note that when the employer gets his first impression of a letter, when he gives it his first reading, and when he gives it a final, thorough, point-by-point analysis, he always pays particular attention to *the way the letter is written* and what that shows about the man's ability. This is his only direct contact with the applicant and his only chance to decide for himself what the man is like, and he uses it to the full.

FIND OUT WHAT KIND OF A JOB YOU CAN FILL

What then can you do to make the way you write a letter show that you deserve consideration for a good opening? The first thing to do is to find out as clearly as possible the kind of job you want, for you cannot possibly write a good letter applying for a job until you know this. To find this out, make a list of the things you do well and the kind of work you like to do, and think out, in the light of this, what sort of job you should make your lifework.[1] Then start all over and make a list of what you think would be the most important requirements for success in that type of job and list your abilities against those requirements. If your interests and qualities do not match with those of the type of work you had in mind, start your analysis over again and keep on until you are sure you have found the right sort of job for you and know your qualifications for it.

In doing this remember there are two types of requirements for every job. First, there are the requirements that are special to the particular job. What these are I cannot tell you, as they are different for every job. But after you are clear as to the sort of job you want, you will be able to puzzle these out fairly well for yourself. Second, there are the general requirements that are essential to being a first-rate employee on any job. Among such requirements are honesty, poise, capacity for orderly intelligent thought, common sense, resourcefulness, modesty, force, willingness to work hard, perseverance, capacity to deal with people, and, above all, an enduring desire to make the job your lifework.

Why do I emphasize this last quality? Because at the present time many men are far too willing to take any job they can get, and all employers know that people who are willing to take any job are rarely willing to keep working hard at any one job long. When it gets hard or they have worked at it for long, they get restless and try another. If an employer has a good job, he doesn't want to invest his money and time in training for it a man who isn't going to stick to it. So one of the first things an employer looks for in choosing a man for a job is how clearly the applicant knows the sort of work he is fitted for and wants to do, and how much evidence the applicant gives by what he says and how he says it that he will continue to like it and stay on. Don't forget this when you come to writing your letters.

ASSEMBLE THE EVIDENCE WHICH SHOWS YOUR FITNESS

When you know what job you want, the qualities it calls for, and the qualities you have that fit you for it, you must decide upon the company or companies you desire to work for and learn what you can about them. Then you come to a particularly hard stage in letter-writing—getting down opposite each of the qualities and interests on your list careful notes as to just what evidence there is that you really have that quality or interest, and are not fooling yourself in regard to it. What have you done or what are you doing that convinces you that this is a quality or interest that you have? Think this out carefully because until you have done it you are certainly not in a position to persuade anyone else that this quality is yours. But even this is only evidence that shows *you* what you have to offer. You still must go over each quality again and plan out the best possible way by which you can convince somebody else that you have it.

Remember that the employer will be influenced by three types of evidence and you must use all three. The first is the record of what you have done in the past. Carefully select the few facts in your record that really show what you are fit for and state them concretely and briefly. Do not try to make your record do too much. Many of your most important qualities can best be shown by other means. So stick to the essentials

[1] The mere fact that you may have an engineering degree does not solve the problem of what lifework is best for you. You may be better suited for technical operating than for designing. You may be better at sales, or teaching, or general management than at either of these. Engineers have found themselves best suited to and made outstanding success in a wide variety of careers.

of your record and cut out everything else. The employer is too busy to read a mass of detail. Show what you have accomplished rather than what opportunities were given to you. If you have a school record show your position in the class. If you have had jobs, show whether you were promoted, what salary you got, and any concrete evidence that indicates how well you did the job—not merely what the job was.

Above all, stick to facts and state them simply and directly. Let the employer make his own inferences as to what they show. If you make claims about your qualities it will not convince the employer that you have them. Instead it will brand you as a "blowhard" and do more harm than good. It is surprising how many sensible men make this mistake, and even more surprising to them when they find out how much harm it has done.

The second sort of evidence that will carry weight with the employer is references which enable him to check up on your record and to find out about qualities of mind and character which are not disclosed by it. If possible, get the permission of the men you use as references to refer to them and in your letter say you have done so.

THE WAY YOUR LETTER IS WRITTEN IS IMPORTANT EVIDENCE

The third, and by far the most important, evidence by which the employer will decide whether you have or lack the qualities which the job requires is the way your letter is written. For unless the letter makes a good impression, the employer will not take the trouble to write to the references; and unless the way the record is stated, as well as the record itself, shows that the writer is qualified for the job, the employer will assume that the record is a record of lost opportunities to learn, no matter how great those opportunities were.

Moreover, most of the important general qualities you possess can only be shown by the way your letter is written. You can't, for instance, tell an employer in words that you are honest or have force of personality. Nor can you show this in your record. But you can show it by what you say and the way you say it. This will start telling the employer about you as soon as he opens the letter. It will tell him more and more, the more carefully he reads.

Everything about the letter will count whether you want it to or not. There is no escape. If your letter is sloppily written, if it lacks neatness, or if it is put together loosely, the employer will know that you are not the man he wants. He doesn't need to figure out whether the defects are due to carelessness, lack of determination and thoroughness, indifference about the job, or just lack of sense enough to know that every aspect of your letter will be taken as typical of your best. Any one of these defects is enough to tell him that he doesn't want you.

WATCH TELLTALE DETAILS

Even very minor defects in a letter may do a great deal of harm. For example, I have on my desk now a letter of application from an enlisted man written on stationery which has in the upper corner "Address Reply to Commanding Officer." I know that doesn't make sense in a letter from an enlisted man who is applying for a job. But the fact that the writer did not notice this himself makes me wonder how careful he would be in business and whether he would notice the kind of things that make the difference between success and failure.

If you pick out trivial facts about yourself, the employer will both be bored and think that you are trivial. On the other hand, if you tell only commonplace facts about yourself and give no individual detail he will think that you are commonplace, and your letter will be dull and make no individual appeal. If you leave out important facts he will know you lack thoroughness and discrimination. It is a hard balance to strike, but if in doubt, be brief. If you make claims about yourself or are self-interested, the employer will think that you lack modesty. If you write inconsiderately, tactlessly, or in such a way as to show that you don't know how to understand and handle people, if you are pompous, flippant, or "smart aleck," the employer will judge you accordingly.

Of course the kind of job you apply for will not only determine the special qualities the employer will look for but influence the general way in which your letter will be judged. If you are only looking for a trade job, although points such as grammar and orderly forceful statement will still count, they will not count as much so long as the letter shows care. On the other hand, if you want an executive or office job and especially if you have had a college education, such slips are fatal. If you want a selling job, however, and write a letter that while careful, accurate, and neat is unexciting and has no sales appeal, the employer will know you are not a salesman. Each letter must be suited to the job it is aimed at and to the record of the man who writes it. That is why so few rules apply, and why you must work out for yourself what is good.

WRITE THE FIRST DRAFT AT ONE SITTING

Plan out carefully not only the significant points of your record and the proper references to cite, but also just what qualities in your stationery, writing, wording, and selection of facts will show that you have the desired qualities and do not possess undesirable ones. This done, sit down and write the letter all at one time. Unless you do this your letter is likely to be "overworked" and heavy. No employer wants to hire somebody who is going to be a bore. So write the letter with a light heart and all the "pep" you can muster.

After you have written the letter, check it over against your notes to see how well you have done what you planned to do. Be careful in making changes not to lose the snap of your first draft. Be sure that the changes make it better as a whole as well as in particular. Be sure that you neither add points which make your letter long-winded nor cut out the things that give your letter individuality. To stick to the essential points does not mean that you must be dull in stating them or omit those few significant details that make you an individual in the reader's mind. Few faults are as bad as being colorless. With so many men looking for jobs, the employer can give personal attention only to applicants whose letters are vigorous and show the writer as an interesting and forceful individual.

Now put the letter away again, preferably for a couple of days. Then get a friend to read it out loud to you, so that you will learn how it will sound to the employer. Then read and reread it yourself making further corrections. Watch everything—both details and the general effect—you can't be too careful. Then, and only then, get the best possible stationery, copy your letter with extreme care and again get someone else to read it over to be sure that there is no slip in grammar, punctuation, or otherwise that has failed to catch your eye because you have worked on the letter so long. Also be sure that in working on the letter so long you have not made it lifeless.

A HARD WAY BUT THE BEST WAY

This is a slow hard way to write a letter. I do not know any harder. But in your letter of application one of the most important things that the employer will look for will be your thoroughness, perseverance, and interest in trying to get the job, and the only way you can make your letter show this is by thoroughness, perseverance, and intelligent interest in writing your letter. Today there is hard competition for the good jobs and you cannot afford to neglect anything that will make your letter down to the last detail the very best you are capable of. Even if you spoil a week end and several evenings in making your letter a little better it will be well worth while. For you are trying against hard competition to get a job that will give you the best possible start on your lifework.

BRIEFING THE RECORD

Abstracts and Comments Based on Current Periodicals and Events

Honors

American Welding Society

AT the annual meeting of the American Welding Society, held in New York in October, 1945, Dr. D. S. Jacobus was elected to honorary membership. For 22 years Dr. Jacobus taught at Stevens Institute of Technology, from which he was graduated in 1884, and in 1906 he took up duties at the Babcock and Wilcox Company which he actively pursued until his retirement in 1941. He has served as president of three national engineering societies, the American Society of Refrigerating Engineers, the American Welding Society, and The American Society of Mechanical Engineers. He became a member of A.S.M.E. in 1889 and was elected an honorary member in 1934. He has received many honors and medals in recognition of his services to the engineering profession. Few names appear more frequently in A.S.M.E. publications as author and contributor to discussions of technical papers. For many years chairman, and now honorary chairman, of the A.S.M.E. Boiler Code Committee, Dr. Jacobus has probably allowed few days of his active life to pass without spending some part of them on business connected with the Committee and the Code. Now in his eighty-fourth year he can be found at the Engineering Societies Building in New York whenever the Boiler Code Committee is in session. Although it is difficult to believe it today, there were times when the Boiler Code Committee had to fight for its existence and for recognition of the codes it promulgated. A large measure of credit for the universal recognition today accorded the Committee and the codes belongs to Dr. Jacobus, for he possesses not only technical knowledge and competence but also those rarer qualities of leadership and persuasion. No better evidence of the respect and affection in which Dr. Jacobus is held can be adduced than the fact that he is best known as "Doctor" and "Jakey."

Other honorary members elected by the American Welding Society are H. C. Boardman, member A.S.M.E., research engineer of the Chicago Bridge and Iron Company, Chicago, Ill., a member of the A.S.M.E. Boiler Code Committee; and H. H. Deppler, chief engineer, Metal and Thermit Corporation, New York, N. Y., second president of the A.W.S.

Wendell F. Hess, professor of metallurgical engineering and head of the welding laboratory, Rensselaer Polytechnic Institute, Troy, N. Y., was elected president of the American Welding Society.

Perkin Medal

Francis C. Frary, director of research, Aluminum Research Laboratories, Aluminum Company of America, will receive the Perkin Medal of the Society of Chemical Industry in recognition of his outstanding accomplishments in the field of industrial research.

Gantt Medal

John M. Hancock, partner in the banking firm of Lehman Brothers, New York, N. Y., and co-author of the Baruch-Hancock report, was awarded the Gantt Medal, at a dinner of the American Management Association in New York on October 10. The Henry Laurence Gantt Memorial Gold Medal is awarded by the A.M.A. and the A.S.M.E. for distinguished achievement in industrial management as a service to the community. Harold V. Coes, past-president A.S.M.E. and chairman of the Board of Award, made the presentation; and Bernard M. Baruch, co-author of the Baruch-Hancock report on reconversion of industry from wartime to peacetime basis, congratulated Mr. Hancock. W. L. Batt, past-president and honorary member A.S.M.E., and chairman of the board of the American Management Association, presided at the dinner.

John Fritz Medal

On Sept. 27, 1945, the John Fritz Medal Board of Award announced that Zay Jeffries had been awarded the John Fritz Medal for 1946 for "leadership in the solution of problems affecting the production, conservation, substitution, and scientific appraisal of metals and alloys."

The John Fritz Medal, established in 1902 by the A.S.C.E., A.I.M.E., A.S.M.E., and A.I.E.E., and called the "highest award in engineering" is given for notable scientific or industrial achievement. It is international in scope, having been awarded to Lord Kelvin, Sir Robert A. Hadfield, Marconi, as well as such American engineers as Westinghouse, Bell, Edison, Elihu Thomson, General Goethals, Orville Wright, Sperry, Herbert Hoover, Whitney, Kettering, and others.

Dr. Jeffries is vice-president of the General Electric Company in charge of the chemical department at Pittsfield, Mass., and was formerly technical director of the lamp department. He is a past-president of the American Institute of Mining and Metallurgical Engineers.

United Engineering Trustees

J. P. H. Perry, vice-president of the Turner Construction Company, New York, N. Y., was elected president of the United Engineering Trustees, Inc., on Oct. 25, 1945. United Engineering Trustees, Inc., is a corporation set up by the A.S.C.E., A.I.M.E., A.S.M.E., and A.I.E.E., the four national engineering Founder Societies, to promote the advancement of the engineering arts and sciences through two departments, The Engineering Foundation and the Engineering Societies Library. It currently has total assets of nearly three and one-half million dollars, not including the value of the Library, and is titular owner of the Engineering Societies Building and of the trust funds of the Library, the Foundation, the John Fritz Medal Board of Award, and the Daniel Guggenheim Medal Board of Award.

New Editor of "Science"

Dr. Willard L. Valentine, professor of psychology and chairman of the department of psychology at Northwestern University, has been named editor of *Science*, a weekly journal, since 1900 the official organ of the American Association for the Advancement of Science, edited from 1895 until his death on Jan. 20, 1944, by Dr. J. McKeen Cattell. A *Science* Policy Committee, appointed about a year ago by the Executive Committee of the A.A.A.S. Council, made a survey of the kinds of material published in *Science* and the amount of each kind and

has made a number of recommendations. A committee on nominations for the editorship of *Science* was also appointed by the executive committee. A memorandum addressed to members of the A.A.A.S. Council brought 70 replies in which nominations were made and 35 without nominations. These replies were considered by the nominating committee and a report was made to the Executive Committee, which subsequently appointed Dr. Valentine.

The *Science* Policy Committee also recommended election of 16 editorial advisers for *Science*, one from each of the active sections of the Association and one at large, and presented to the Executive Committee two or more nominations for each advisory post. Election of advisers is by mail ballot of the Council and the term of office is four years. In order that only four advisers shall be elected in any one year, dates of expiration of term of office have been set in the initial election. The adviser elected for the Section on Engineering is J. C. Hunsaker, of the Massachusetts Institute of Technology, honorary member A.S.M.E. Dr. Hunsaker's term expires Dec. 31, 1946.

First James Clayton Lecture, I.M.E.

The first James Clayton Lecture of The Institution of Mechanical Engineers was delivered on Oct. 5, 1945, by Air Commodore Frank Whittle, R.A.F., honorary member I.M.E. The lecture dealt with the early development of the Air Commodore's system of jet propulsion and the title, "The Early History of the Whittle Jet-Propulsion Gas Turbine." The James Clayton bequest, under which the lectureship is inaugurated, consists of a considerable sum of money bequeathed to The Institution of Mechanical Engineers by the late James Clayton, "who was directly concerned with the solution of many problems which had to be overcome before the manufacture of rayon became commercially practicable, and who was closely associated with the development of special devices, notably spinning machines, washing machines, and bleaching machines. . . He spent long periods in the U.S.A. on behalf of the company (Courtaulds), and was largely responsible for the selection of the sites and the design and construction of the first rayon factories built by Courtaulds in that country."

British War Production

A RECORD of British War Production, compiled by *The Times* (London), has recently appeared. It fills 32 pages of the normal size of *The Times* and covers all branches of the war production from 1939-1945 in summary, with many illustrations. In a foreword by the Rt. Hon. Oliver Lyttleton, Minister of Production from March, 1942, to July, 1945, it is stated that victory "was won not only on the battlefield, on the sea, and in the air, but in the workshops and factories of the Allied Nations."

"Of all the munitions used by the Armed Forces of the British Commonwealth and Empire ($8^3/_4$ million men in all) since the beginning of the war)," the Minister says, "no less than 70 per cent was produced in the United Kingdom itself. . . In addition to what we produced for our own Forces and those of the Commonwealth and Empire," he continues, "we made and sent substantial supplies to our other Allies—the United States Forces in Britain, the U.S.S.R., China, and others of the United Nations." Citing the extreme difficulties under which this production was carried on, made possible only by the great labors and heavy sacrifices of the British people, he says: "All men up to age 64 and all women to age 59 were mobilized; food, clothes, petrol were severely rationed; and supplies of everyday things drastically limited. Our export trade too had to be deliberately curtailed, so that in 1943 and 1944 it was less than one third in volume of the 1938 level."

"During all this great outpouring of effort the quality and ingenuity of British production have been more than maintained. We were the pioneers of radar and jet propulsion; it was a British scientist who discovered penicillin, a British engineer who designed the Bailey bridge; we designed and built the Mulberry harbors which made the invasion of France possible; British aircraft have proved themselves second to none in the world; and British scientists collaborated with American and Canadian scientists to develop and produce the atomic bomb."

Atomic Power

AT the close of a stimulating address, "Atomic Power in War and Peace," delivered at a meeting of the Chicago Association of Commerce, Oct. 9, 1945, Arthur H. Compton, chancellor of Washington University, St. Louis, Mo., listed four major immediate consequences of atomic power as follows:

(1) It makes inevitable a world government. If we are wise, we shall take immediate steps to form this government by international agreement instead of waiting for a third world war of unparalleled destructiveness to determine the ruler of the world.

(2) Until this world government is established, the United States should limit its defense preparations to ability to reply to any attack that may be made against us with such strength as to devastate our enemy's important surface installations. This is a defense objective which we can achieve without seriously straining our national resources.

(3) The most important immediate peaceful application of atomic energy is that of supplying heat and power from large installations, especially in areas where power is now relatively expensive. The indications are that for such purposes atomic power will before many years be competing with coal on favorable terms. These and other applications of atomic processes may have considerable effect in extending industrial frontiers.

(4) The best assurance of national safety in the atomic age, both before and after the establishment of a world government, is to develop the nation's maximum human and industrial strength. This requires keeping all essential industries vigorously alive and enabling every citizen by appropriate training and employment to contribute to the common welfare as his abilities may permit.

Dr. Compton, until July of this year dean of the Division of Physical Sciences, University of Chicago, recipient of many honors, including the Nobel prize in physics, 1927, is chairman of the National Academy of Science's Committee on the use of uranium in war, a member of the scientific panel appointed by the Secretary of War to advise regarding atomic energy, and was from 1941 to 1945 director of the "Metallurgical Project" to which was assigned the responsibility for initiating the research on atomic bombs, for developing the methods for producing plutonium, and for investigating the possibilities of atomic power.

All of this distinguished scientist's Chicago address is worth study, but engineers will find greatest interest in the section on the industrial meaning of atomic energy from which the following portions are quoted:

"In the long run it can hardly be questioned that the peaceful applications of atomic energy will be those that will most profoundly affect our lives. What these important applications will be is, however, as difficult to predict as it would have been a century ago, just after Faraday had laid the scientific basis for electrical engineering, to tell the future meaning of electricity. At this moment the obviously great field open to atomic energy is that of production of useful heat and power. We also see important though limited medical and industrial applications of radioactive materials, artificially produced by atomic chain reactions. Perhaps more significant than either are the new vistas that will be opened up by scientific experiments that make use of the by-products of atomic fission.

"Such has indeed been the case with such discoveries as X rays. Fifty years ago it was obvious that X rays were useful for seeing through objects opaque to ordinary light such as the human body. It could not be predicted that X rays would become a powerful weapon in the fight against cancer, or that researches made possible by X rays would reveal the electron and with it give us the radio and a host of electronic devices. Such unforeseen developments are the result of every great discovery of science. Now, however, you want to know what we can clearly see before us.

"At present, controlled atomic power in the form of heat is in continuous production in large quantities at several plants especially those at Oak Ridge, Tenn., and at Hanford, Wash. The heat from these plants is a by-product and is carried away in the one case by air and in the other by a stream of water. The useful product is neutrons, which are used in the plants as a means of transmuting certain chemical elements to others of especially useful characteristics. Of these transmutation processes the most important one is that of uranium into plutonium. Previous to the fission chain reaction, the most abundant source of neutrons was the cyclotron which operates on electric power. Per kilowatt of energy used, the fission chain reaction gives some 10,000 times as many neutrons as a cyclotron, and it is not difficult to make a fission chain-reaction plant that delivers 100 times as much power as is used by a cyclotron. This means that right now we are using large amounts of atomic power many times more efficiently for the particular process of producing neutrons than the best electrical machine that we have been able to devise.

"We have not yet built an atomic power plant that is generating electrical power. This is merely because we have been engaged in winning a war, and there has been no serious shortage of electric power. If there were sufficient reason for a demonstration, a reasonably efficient plant using superheated steam for driving a turbine could be put in operation within a year. Before, however, such plants can be made economical competitors with existing practice, a number of years of development will be required.

"While there are several other possibilities, the most obvious method of producing power from atomic fission is to heat a cooling agent such as air or steam or liquid metal in the chain reactor unit, and pass this heated coolant through a heat exchanger which heats the steam for driving a turbine. Beyond the heat exchanger of such a plant everything would be done according to standard practice. Up to the heat exchanger all the design requires new features, among them protection against the extreme radioactivity of everything, including the coolant, that has been exposed to the neutrons.

"The chain reacting unit itself can assume many forms. The one essential is that it shall contain uranium, either in its natural state, or if a small unit is desired, enriched with additional U-235 or plutonium. H. D. Smyth, in his official report, has described in some detail how this active material can be combined with a moderator such as carbon or beryllium or heavy water so as to bring about the chain reaction.

"The large atomic power plants now used for producing plutonium have in them many tons of natural uranium and graphite. By using uranium containing more than the usual fraction of U-235, chain reacting units have been built that are of much smaller size.

"There is, however, a lower limit to the size and weight of an atomic power plant that is imposed by the massive shield needed to prevent the neutrons and other dangerous radiations from getting out. Next to cosmic rays, these radiations are the most penetrating that we know, and for a plant designed to deliver, for example, no more than 100 horsepower, are enormously more intense than the rays from a large supply of radium or an X-ray tube. To stop them, a shield equivalent in weight to at least 2 or 3 feet of solid steel is needed. There are basic laws of physics that make it appear very unlikely that a lighter shield can be devised. This means that there is no reason to hope that atomic power units for normal uses can be built that will weigh less than perhaps 50 tons. Driving motorcars or airplanes of ordinary size by atomic power must thus be counted out.

"Prominent among the advantages of atomic power are the extraordinarily low rate of fuel consumption and consequent low cost of fuel, and the wide flexibility and easy control of the rate at which power is developed, and the complete absence at the power plant of smoke or noxious fumes. With regard to fuel consumption, when completely consumed, the fission energy available from a pound of uranium is equivalent to over a thousand tons of coal. With the prewar price of uranium oxide at roughly $3 per pound and of coal at $3 per ton, this would mean the economical use of uranium as fuel if only one part in a thousand of its available energy is used. Actually, we should expect the first plants built to deliver atomic power to be considerably more efficient than this in their use of the fission energy, which would mean a substantial cost advantage in favor of uranium. One must consider also, however, the need to purify and fabricate the uranium into the desired form. For certain types of power plants under consideration, a considerable amount of separated U-235 is required. Attempting to consider all such factors, it appears that the fuel cost of the atomic power plant of the future will be small as compared with the corresponding fuel cost of a coal-burning plant.

"In considering the economic aspects there are, however, many other factors. It is not really possible for these to be explored until we have actual experience with atomic power plants. First is the capital cost. Clearly, if one must charge against this cost what is spent in research and development, this capital cost is very high indeed. If, however, one looks down the line to a billion-dollar-a-year national industry based on atomic power, the nation can afford a considerable investment in the research and development required to bring this industry into being. When this development is done, it appears not unlikely that the cost of building and maintaining a large-scale atomic power plant may compare favorably with that of a coal-consuming plant of the same capacity.

"Much remains to be learned, however, regarding the metallurgical and other technical problems involved in constructing a successful plant to transform fission energy efficiently into high-temperature heat. The materials to be used may be expensive. The designs are, however, essentially simple. An inherent advantage of the atomic power unit is that the heat sources, i.e., the uranium blocks, can readily be maintained at any desired temperature regardless of how rapidly the heat is being removed. This means that a relatively small-sized heater unit will be needed, and that corrosion due to excessive heating is controllable.

"One notable limitation to the use of atomic power is the need for careful protection against harmful rays. Explosions such as destroyed Hiroshima cannot occur accidentally. Such explosions must be planned for. The dangers of explosions of the boiler type with an atomic power plant are about the same as with a steam plant, which is to say they are practically negligible if the plants are designed and handled by competent engineers. There is, however, real possibility of damage to the operating personnel from ionizating rays emitted by the plant itself and by all materials that are taken out of the plant. It is the problem of the radium and X-ray workers on a grand scale. That the problem can be solved is shown by the fact that in all of the operations of the half dozen or more such plants, some of which have now been working for years, not a single serious exposure has occurred. This, however, is due to thorough instruction and vigilant care by Dr. Robert Stone's health staff. In some of the experimental work we have not been so fortunate. This means that until we become much more familiar with nucleonics than we are at present, atomic power plants

can be safely operated and serviced only with the help of health supervisors who are familiar with radiological hazards.

"All of this points toward using atomic power first in relatively large units where careful engineering and health supervision can be given. An obvious suggestion is its application to the power and heat supply of cities and large industrial plants. Within ten years it is not unlikely that the power companies designing new plants for city service will be considering favorably the use of uranium instead of coal for purely economic reasons.

"This of course does not mean that atomic power will put coal out of business. Each will have its own field. For small heating units, such as the kitchen stove, atomic power has no place If our national economy grows as it should, coal as a chemical agent, as for example in blast furnaces and preparation of organic chemicals, will increase in importance.

"From the point of view of the national economy the introduction of such a new source of power is a clear gain. If it will lessen the cost of heat and power to our cities, it will be a stimulus to every industry. If it reduces the pall of winter smoke, it will be a boon to us all. If it gives cheap power where industry and agriculture need it but cannot now get it, it will extend our economic frontiers. These are possibilities that lie immediately before us."

Superspeed Aircraft

IN hearings before the House Committee on Appropriations Russell G. Robinson, chief of research co-ordination of the National Advisory Committee for Aeronautics, said that the work load on the N.A.C.A.'s high-speed wind tunnels was "critical," and that the industry, in order to meet the military's requirements for aircraft in the "superperformance category," would like to have "five times as much research data in the next six months as can be obtained from the existing high-speed wind tunnels."

Robinson described a recent meeting at Wright Field with the designing engineers of 24 manufacturers of high-speed aircraft and engineering groups of the Army and Navy air arms at which a proposed research program was studied for two days and the most important problems were selected. The urgency came, he said, from the necessity of fixing on the manufacturers' final airplane designs within the next few months and from the extreme complexity and difficulty of the problems to be solved in the flight region around the speed of sound. In meeting demands for flight at transoceanic speeds (from 500 to 700 mph) and at supersonic speeds (more than 700 mph), he stated that for those speed regions each phase of airplane design required many times the amount of research data that used to be used because of interactions between aerodynamic problems, structural problems, and power-plant problems. "We used to be able to isolate problems in these different fields and solve them separately," he said, "but now they are intermingled so we cannot solve one of them without thorough consideration of the others. The result is a manifold increase in the technical effort required for a single aircraft design in the ultraspeed range."

Free-Piston Compressor

THROUGH the courtesy of the Technical Information Division, Office, Chief of Engineers, War Department, we are able to present the following description of a free-piston compressor of German design.

A German-manufactured air compressor, captured from the Japanese, may furnish the blueprint for an improved piece of equipment for the United States Army, according to a report from the Engineer Board at Fort Belvoir, Va., to the Office of the Chief of Engineers, Washington, D. C. This report covers "Compressor, Air, Free Piston, High Pressure, 3000 Psi, Integral Diesel Drive, 3000 Cfh (est.), Serial No. 153, Engineer Board Registration No. 346." This is the same Junkers design noted in MECHANICAL ENGINEERING for April, 1935.

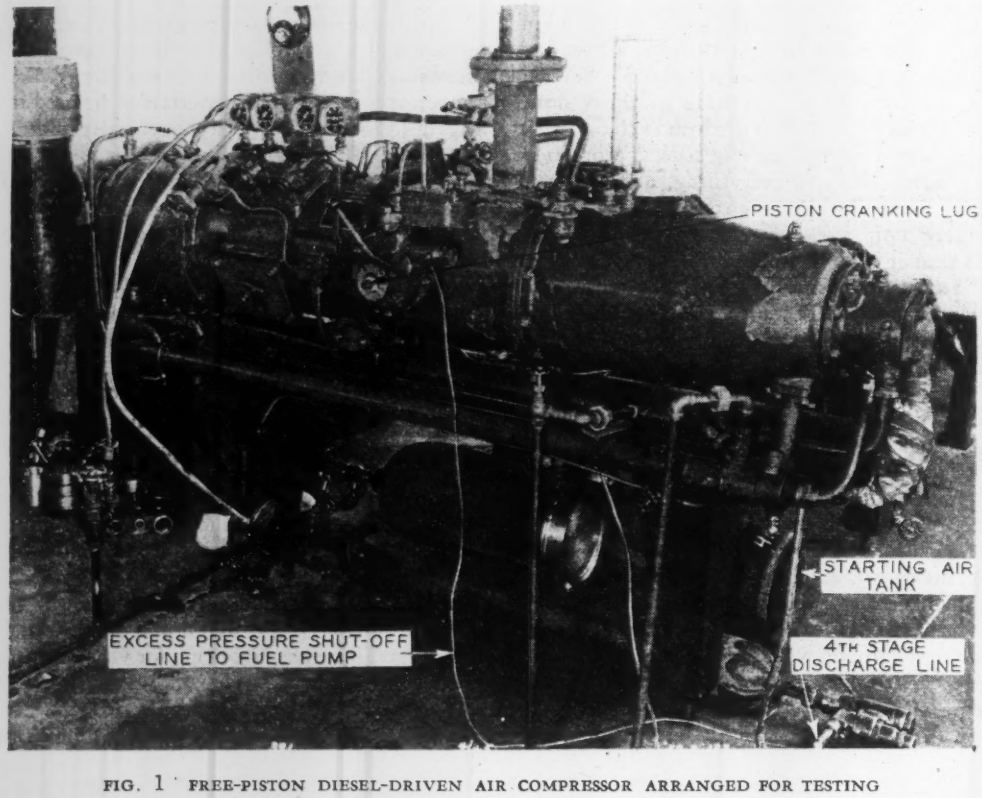


FIG. 1 FREE-PISTON DIESEL-DRIVEN AIR COMPRESSOR ARRANGED FOR TESTING

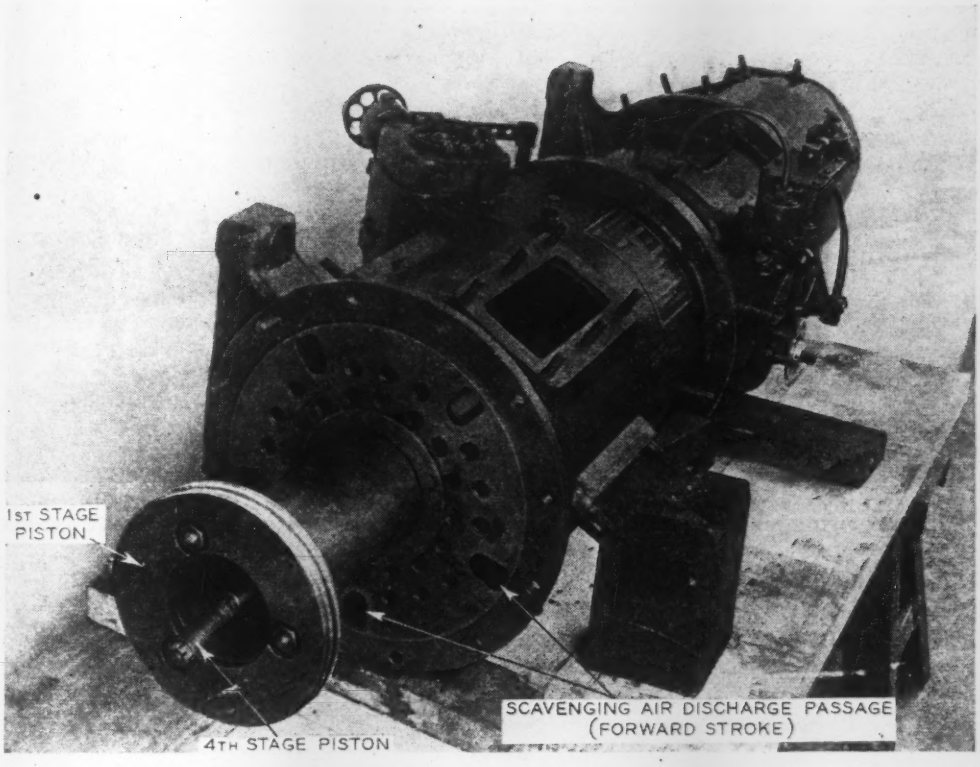


FIG. 2 FREE-PISTON AIR COMPRESSOR WITH OUTER CASING REMOVED TO SHOW FIRST- AND FOURTH-STAGE PISTONS

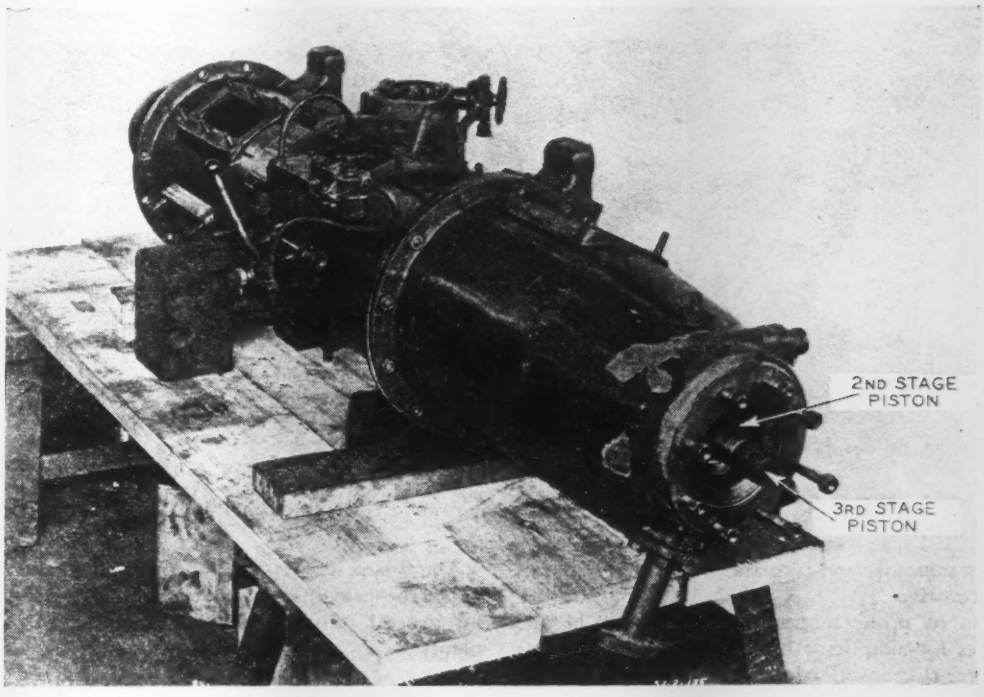


FIG. 3 FREE-PISTON AIR COMPRESSOR SHOWING SECOND- AND THIRD-STAGE PISTONS

The Engineers have, according to the report, learned that the machine was one of six supplied by Germany to Japan. The fate of the other five is unknown but this particular high-pressure air compressor with integral Diesel drive was shipped to the Engineer Board from the Aberdeen Proving Ground as an unidentified piece of equipment. This "free-piston compressor" as it shall be called, is cylindrical in form, completely enclosed and very compact of construction. It may be divided into three sections, the engine part being located in the center and the compressor sections at each end.

The engine consists of the engine housing with interchangeable cylinder liner in which two "free" engine pistons operate. The absence of valves and complicated valve gear, as well as the conventional crankshaft and connecting-rod drive, makes for simplicity and compactness. Fuel is supplied to the cylinder through an open nozzle of the Junkers design.

The compressor pistons also work in interchangeable liners. On each air compressor there are two pressure stages. The compressor pistons on each side are rigidly connected with the corresponding engine piston. All suction and discharge valves

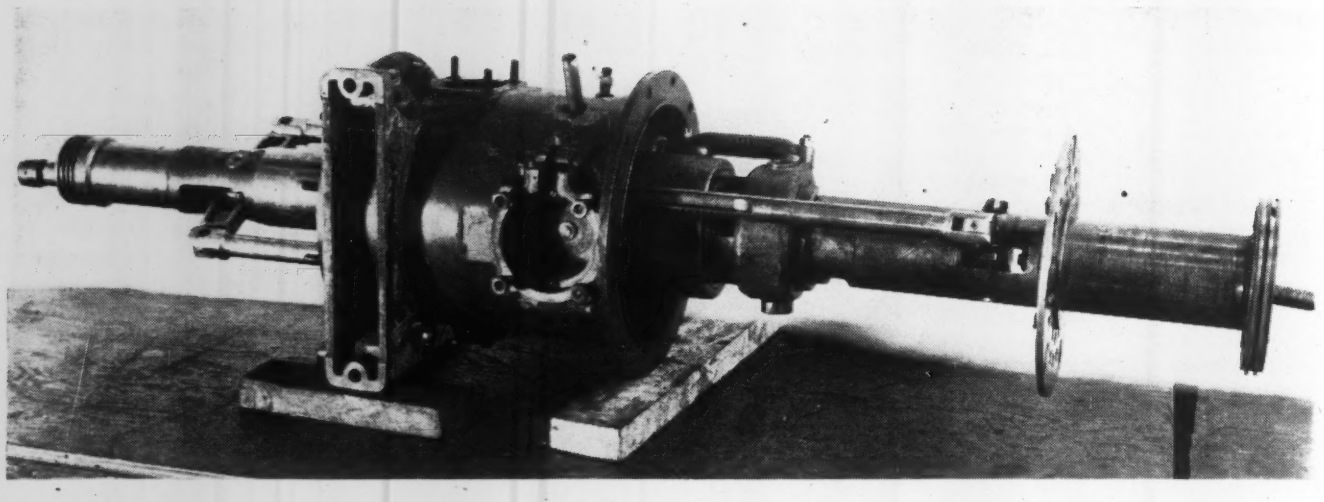


FIG. 4 FREE-PISTON AIR COMPRESSOR WITH CYLINDER CASINGS REMOVED TO SHOW THE FOUR PISTONS

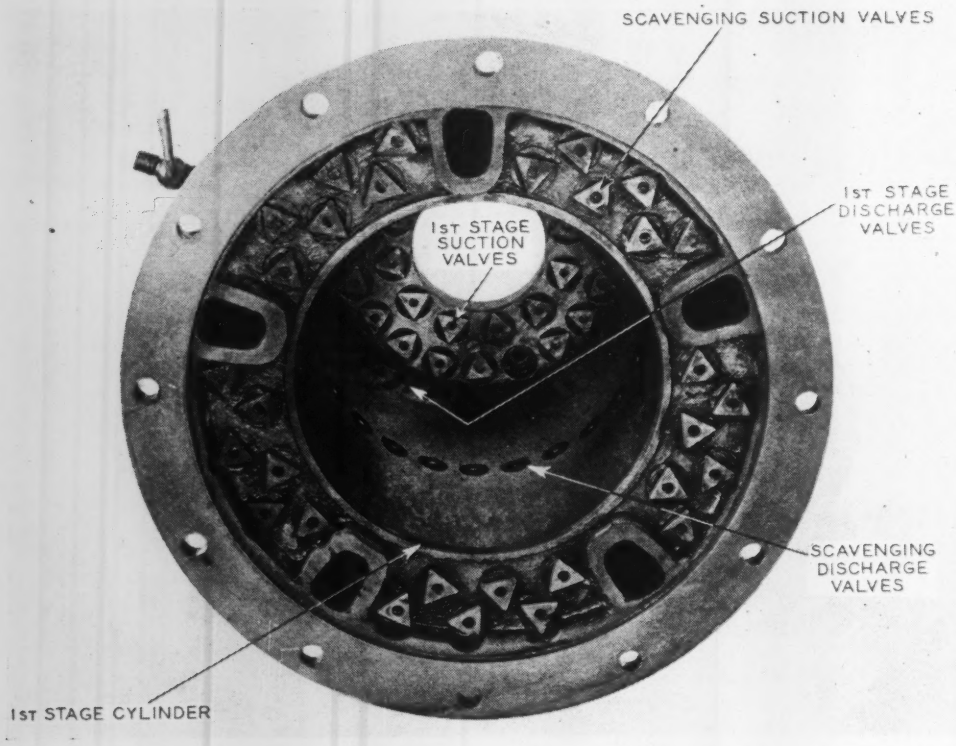


FIG. 5 SOME OF THE VALVES OF THE FREE-PISTON AIR COMPRESSOR

employed are of the same size and type and are fully automatic, spring-loaded, plate valves.

The combination of prime mover and compressor in one integral unit makes for simplicity in construction, minimizes vibration to a degree that installation without a foundation is permitted, simplifies servicing and maintenance, and reduces the weight to a surprisingly low figure as compared to conventional compressors.

It is thought that the Japanese may have used such a compressor in a submarine or as a source of high-pressure air for flame throwers or oxygen plants.

A specific instance where it may be of value would be as a source of air in the new type liquid-gaseous oxygen plant proposed for standardization by the Corps of Engineers. It is estimated that successful operation of a 120-cfm compressor in such a plant would represent a weight saving of approximately eight tons by eliminating two of the 60-kw generating sets in addition to the advantages just cited.

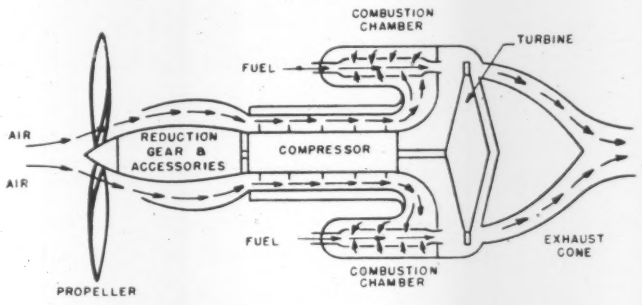
The Board further recommends that further consideration be given the principles involved in the "free-piston compressor" for general military use and especially for use with oxygen plants.

Aircraft Engines

GENERAL MOTORS has announced a new aircraft engine, rated at 200 hp. It is of the radial type, has four cylinders, and operates on the two-stroke cycle. Its unique feature is said to be a supercharging blower to increase performance and power reserve for take-off and altitude. There are no valves. Although the piston displacement is only 250 cu in., the size of an automobile engine, the new engine develops normally 200 hp with a high safety factor and its weight dry is 275 lb. It is said to be the only small engine having liquid cooling and may be installed for the same weight as an air-cooled engine.

Its diameter is only 35 in. Oil consumption is said to be low, one quart of oil serving for 6 hours' running. Fuel consumption is about 13 gal per hr using 91-octane fuel. Tests are said to have shown that the added cost and weight of a variable-pitch propeller can be eliminated by use of the boosted two-cycle principle. The design is simplified and the number of parts is reduced, thereby permitting a rugged type of mechanism with minimum field-maintenance costs.

General Electric has announced development of an airplane power plant consisting of a gas-turbine-driven propeller and a jet, which has been designed primarily to drive large high-speed military transports and bombers. It has been subjected to test-stand runs and in June, 1945, was installed in an experimental Army Air Forces plane. The general arrangement of the principal parts of the power plant is shown schematically in



G-E PROPELLER DRIVE GAS ENGINE

FIG. 6 SCHEMATIC DIAGRAM OF G. E. PROPJET

Fig. 6. The gas turbine with propeller is designed for installation in the wings of multiengined aircraft or in the nose of a single-engine plane. It is said that the "propjet" type of power plant, as it is called, will make it possible for planes to be powered by smaller, lighter-weight engines, which are of simple and compact design, producing negligible vibration. The fuel used to date has been kerosene, although the gas turbine can be designed for other liquid fuels. The range of planes powered by gas turbines of this type will be extensive. At slow speeds and at low altitudes the gas turbine uses more fuel than the reciprocating engine under similar conditions, but when operating at full power the turbine uses less fuel than a conventional reciprocating engine operating at maximum power. The gas turbine functions most efficiently at high altitudes.

The speed limits on planes powered by the new turbine are unquestionably the compressibility barriers that are reached by all propeller-driven planes somewhere slightly above 500 mph. Planes powered by the propjet units can operate over long ranges at speeds close to this compressibility wall while planes driven by reciprocating engines cruise on long flights at reduced speeds. Planes powered by these new gas turbines may not reach the extreme high speeds attained by the newest AAF fighter, the jet-propelled Lockheed P-80. On propeller-driven aircraft, the propeller blades spinning at high speed are the first part of the plane to be affected by the compressibility barrier. The P-80, being jet-propelled and having no propeller, has eliminated the problem and permitted top plane speeds closer to the compressibility wall now limiting speeds of our fastest planes. However, engineers are of the opinion that while the new propjet type of gas turbine may not power our fastest planes, it will give ranges greater than may be possible with pure jet propulsion.

Lithium

THE following facts about lithium are quoted from the *Industrial Bulletin* of Arthur D. Little, Inc., Oct., 1945, No. 214: Although little known as a war baby, the U. S. production of lithium, lightest of all solid elements, has increased sevenfold during the war. The price of lithium metal, $12.50 per pound in large lots, has not dropped greatly, but some manufacturers predict that, with new production facilities and the hoped-for large postwar demand, a price of $5 may be possible.

The justification for lithium's high cost rests on its extraordinary chemical reactivity and on the results obtainable from small quantities. One of its best established uses is in removing by chemical combination (scavenging) the last traces of oxygen and other impurities from high-quality metals and alloys. This ultimate purification often gives surprising results; the electrical conductivity of copper, for instance, is markedly enhanced, and lithium-purified copper is a regular commercial product. The strength and hardness of 6000 pounds of steel can be improved by the "scavenging" effect of one pound of lithium, generally contained in a "master alloy" with calcium, copper, or zinc. The internal structure of some metals, including lead, zinc, and aluminum, can be controlled by using small quantities of lithium as an alloying ingredient.

An important wartime product has been a lithium compound which on addition of water releases the hydrogen gas used to inflate balloons for carrying aloft radio antennas and signals from life rafts at sea. A one-pound can of this material, slightly bigger than a tomato can, yields enough gas to inflate the balloon, and five pounds of the compound yield as much hydrogen, 235 cubic feet, as would otherwise be transported under 2500 pounds per square inch pressure in a standard cylinder weighing 140 pounds.

Lithium soaps, the reaction product of lithium and fatty acids from animal and vegetable oils, have been extensively used with lubricating oils to make special lubricants and greases. With lithium soaps added, these greases can maintain the proper viscosity and other physical characteristics in high temperatures or low. As a result they have been especially useful in aircraft lubrication.

The ability of concentrated solutions of lithium chloride or bromide to absorb moisture from the surrounding atmosphere is the basis for their use in air-drying, a field in which lithium manufacturers expect an important postwar outlet. In most air-conditioning systems the air is dried by cooling a portion of it more than would otherwise be necessary, so that it cannot hold all the moisture contained in the original fresh air. An alternative method is to cool the air only to the desired temperature and to remove the moisture by passing the air through a spray of moisture-absorbing solution, such as lithium chloride or calcium chloride, or through a solid absorbent, such as silica gel. By this latter means the capacity of refrigeration equipment needed for a given job can be reduced about half, but auxiliary equipment is necessary for heating the absorbent to drive off the moisture so that the absorbent can be used again. For many industrial applications air-drying is needed but cooling is not. For such situations, equipment using a lithium absorbent in a compact drying and regeneration cycle is available.

Air-conditioning equipment which uses gas flame absorption refrigeration instead of mechanical refrigeration and which uses a lithium compound as the absorbent has also recently been introduced. This product has been developed for all-year residential and small commercial air-conditioning applications. The same burners are used for heating effect in the winter and cooling in the summer.

Although lithium is not rare, commercial deposits are few and, up to the present, methods of extraction have been difficult and costly. The best sources are in the United States, in the minerals of North Carolina and South Dakota and in the brines of Searles Lake in California. The wartime expansion of production gives lithium producers a real opportunity to develop outlets in postwar markets.

Of General Interest

THE interesting feature of the radial hydraulic pump shown in section in Fig. 7 is the hollow piston which is said to function like a cup leather (hydraulic pressure forcing the sides of the piston outward to effect a seal against leakage) only these pistons are made of highest-grade tool steel heat-treated to a hardness of 60 Rockwell C to give high strength, elasticity, and good wearing qualities. As the fluid pressure builds up inside the hollow piston it expands and the sealing effect is increased between the moving piston, cylinder wall, and

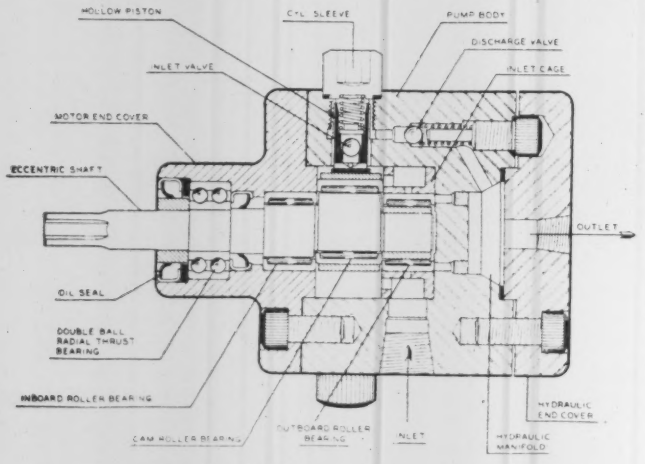


FIG. 7 RADIAL HYDRAULIC PUMP WITH HOLLOW PISTONS

pump body. When the pressure is released all surfaces return to their original dimensions.

Operation of the pump is evident from the cross section of Fig. 7. Motion is transmitted to seven pistons and sleeve assemblies equally spaced radially by an eccentric shaft rigidly supported on two needle roller bearings, one on either side of the eccentric cam. The flanged foot of the piston bears on a third needle roller bearing which floats on the eccentric cam.

The intake characteristics of this pump are similar to those of centrifugal pumps. They are not self-priming and to insure best results they should be installed below the oil reservoir where gravity will automatically keep them primed. After priming they will maintain a vacuum of 25 in. of mercury providing the intake line is airtight. They can be run in either direction. The displacement is constant per revolution. Pressures as high as 10,000 psi are possible.

The foregoing information was taken from a memorandum by T. E. Raymond, inventor of the pump, president, Simplex Engineering Company, Zanesville, Ohio.

FANS

Fig. 8 shows a new thermo-control fan whose principal application is said to be on heavy-duty equipment such as buses, trucks, stationary engines, tractors, shovels, and Diesel engines. It is said to adjust itself automatically to produce economical operating conditions by means of variable-pitch control of the fan blades. This is accomplished by a built-in heavy-duty thermal power element. With the engine at low load or on cold days, the fan blades may be at zero, or reverse, pitch. The thermal power element automatically changes the pitch of the fan blades, through infinite variation, to the maximum which would be required under heavy loads or extremely high ambient temperature.

SILO

The steel silo, glass-coated inside and out, shown in Fig. 9, is said to have the following advantages:

(1) Silage is removed through a 24-in. hopper opening at the bottom which is operated by an engine-driven mechanism which reduces labor and hazard. (2) The engine feeds "burned out" air into the top of the silo to reduce the oxygen which molds must have, thus reducing spoilage. (3) The silo is about one sixth the weight of a standard concrete silo. (4) The cost is comparable to that of a standard silo.

The silo was developed by A. O. Smith Corporation, Milwaukee, Wis.

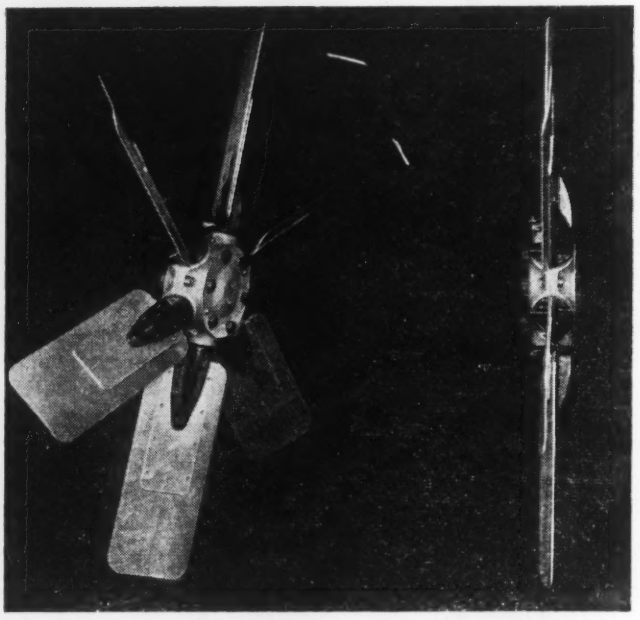


FIG. 8 THERMO-CONTROL FAN

FIG. 9 STEEL SILO GLASS-COATED INSIDE AND OUT

COMMENTS ON PAPERS

Including Letters From Readers on Miscellaneous Subjects

Boiler-Water Treatment

COMMENT BY T. E. PURCELL[1] AND S. F. WHIRL[2]

In a paper recently published,[3] discussing boiler-water treatment at Springdale, the following statements were made:

"Following the introduction of the chlorides, the iron content of the deposits gradually decreased over a period of several months. Adherent deposits were not formed and most of the loose material was removed when a boiler was drained. A typical boiler-water analysis made during this period is given in Table 10."

Table 10 of the paper is repeated herewith.

TABLE 10 BOILER-WATER ANALYSIS AT TIME OF SLIGHT SLUDGE DEPOSIT

pH value	11.0
A reading, epm	2.0
B reading, epm	0.8
Sulphate, SO_4, ppm	249
Sulphite, SO_3 ppm	1
Phosphate, PO_4, ppm	127
Chloride, Cl, ppm	193
Dissolved silica, SiO_2 ppm	7
Sodium, Na, ppm	8
Potassium, K, ppm	581
Total solids, ppm	1260
Cl/OH, epm	6.7/1
K/Na, epm	42.5/1

A study of this analysis indicates that there were changes, other than the addition of chlorides, which may have been equally or more responsible for the observed improvement in boiler conditions. From the pH value and the phosphate and silica concentrations reported, it is to be noted that the boiler-water conditions satisfied all the requirements for (*a*) co-ordinated phosphate-pH control,[4,5] recommended for preventing caustic attack of tube metal, and (*b*) the silica-pH control modification for preventing silica deposits, which the writers proposed in a discussion of a paper by Hall.[6] The pH value of the boiler water was below that of a pure tripotassium-phosphate solution containing 127 ppm of PO_4 ion and, at the same time, above that of a pure potassium-metasilicate solution containing 7 ppm of SiO_2. The relationships are shown in the following table:

	pH value	PO_4, ppm	SiO_2, ppm
Reported in table 10	11.0	127	7
From PO_4-pH curve	11.1	127	..
From SiO_2-pH curve	10.2	...	7

This method of boiler-water conditioning, which we term "co-ordinated phosphate-silica-pH control," has given successful results in Duquesne Light Company boilers for the past 2 years with both sodium and potassium chemicals. A brief discussion of the theory of this method follows:

Caustic Attack on Tube Metal. It is generally agreed that "free" caustic alkalinity accelerates the attack on tube metal in those cases of faulty circulation or excessive rates of heat input. Therefore, any restriction of the concentration of free caustic in the film of boiler water adjacent to the metal may be expected to lower the corrosion rate, and simultaneously reduce the amount of iron-oxide scale or sludge produced in the boiler.

On the basis of Raoult's law, Hall[6] has recommended the use of potassium chloride for this purpose. Based on the same reasoning, any neutral salt which is soluble at the temperatures in question would behave in a similar manner. Such chemicals increase the boiling point of solution, within limits, in proportion to their concentration. In reality, they are "antiboil" substances, as contrasted with the familiar antifreeze compounds used in automobile radiators. The fact still remains, however, that any free caustic present in the boiler water will be concentrated on film-boiling, regardless of the amount of antiboil substances added, although not to the same extent as in their absence.

The question naturally arises, why permit the offender, free caustic, in the boiler-water film when its complete absence can quite simply be insured? The theory of co-ordinated phosphate-pH control is based on this very principle. As long as the pH value of the boiler water is the same as or below that of a pure tripotassium-phosphate solution, containing the same PO_4 ion concentration, no free caustic will be present; on the graph, the PO_4-pH co-ordinate would fall, respectively, on or below the PO_4-pH curve. When concentration occurs with a water of this nature, by film-boiling or any other means, the alkalinity of the solution adjacent to the metal will be limited to the degree of concentration of the salt. Since the alkalinity of a saturated solution of tripotassium phosphate is very weak, as compared with a strong caustic potash solution, the attack on tube metal may be expected to be lowered correspondingly. This would be equally true when the boiler water is treated with the analogous sodium salts. It is further to be noted that boiler-water PO_4-pH values below the curve will yield still lower alkalinities in the concentrated film.

As just pointed out, the boiler water whose analysis is given falls in this category. Consequently, we believe that limiting the alkalinity to that derivable from phosphate salts contributed to the reduction of iron oxide in the boilers reported by the authors.

Silica and Complex Silicate Deposits. To combat the ravenous appetite of caustic in the concentrating film for tube metal, there has been a definite tendency in recent years toward lower boiler-water alkalinities. While this procedure has materially decreased the damage to tube metal, it has accentuated difficulties arising from silica deposits. Hall[6] has given a logical explanation of this behavior, based upon the phase-rule studies of Morey,[7] showing that a SiO_2/K_2O ratio higher than 1.6 yields compounds

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[2] Chief Chemist, Power Stations Department, Duquesne Light Company, Pittsburgh, Pa.

[3] "History of Potassium Boiler-Water Treatment at Springdale," by L. E. Hankison and M. D. Baker, Trans. A.S.M.E., vol. 67, 1945, pp. 317–321.

[4] "Protection Against Caustic Embrittlement by Co-Ordinated Phosphate-pH Control," by S. F. Whirl and T. E. Purcell, Third Annual Water Conference, Engineering Society of Western Pennsylvania, 1942, pp. 45–60.

[5] "Protection Against Caustic Embrittlement by Co-Ordinated Phosphate-pH Control," by T. E. Purcell and S. F. Whirl, Trans. Electro-Chemical Society, vol. 83, 1943, pp. 279–295.

[6] "A New Approach to the Problem of Conditioning Water for Steam Generation," by R. E. Hall, Trans. A.S.M.E., vol. 66, 1944, pp. 457–488.

[7] "The Ternary System H_2O–K_2SiO_3–SiO_2," by G. W. Morey and C. M. Fenner, *Journal of the American Chemical Society*, vol. 39, 1917, pp. 1173–1229.

which are unstable under boiler-water conditions, and therefore they may be expected to decompose with silica deposition in the boiler. The system studied by Morey dealt only with the potassium silicates; the effect on the equilibrium of other chemicals normally found in boiler water remains to be investigated. We know that chemicals like aluminum do affect the equilibrium, and it is logical to assume that other components will alter the phase diagram, particularly salts of weak acids and strong bases, for example, tripotassium phosphate.

In our discussion of Hall's paper,[6] we proposed a theory which considered not only silica deposition as SiO_2, but also the formation of complex silicate scales similar in nature to analcite and acmite. A simple method of boiler-water control was also presented, utilizing two curves relating the pH value to concentration of pure tripotassium phosphate and potassium metasilicate, respectively.

The reasoning on which the theory is based is quite simple and fundamental. From Morey's data, we learn that a solution of potassium metasilicate will not deposit silica on being concentrated. The control procedure is designed to keep the silica in this stable form by maintaining the pH value of the boiler water higher than the pH value of a solution of potassium metasilicate of the same SiO_2 content as that of the boiler water.

The procedure is as follows:

1 Analyze the boiler water for SiO_2.

2 Note the corresponding pH value on the SiO_2-pH curve.

3 Keep the pH value of the boiler water above this point.

According to Morey's data, a solution with a ratio of SiO_2/K_2O of about 1.6 is the richest in silica which is stable under boiler operating conditions. The metasilicate was chosen for our curve to allow a slight safety margin with respect to the pH requirement.

If KOH and SiO_2 were the only substances present in the boiler water, the conditions would be similar to those in Morey's experiments, and we could be reasonably sure that application of the proposed control procedure would hold the SiO_2 in solution. However, other chemicals are always present to exert some effect on the equilibrium, and while postulations may be reasonably correct, actual tests are required to determine the true behavior of the silica.

So little is known about the chemistry of the complex silicate scales that preventive efforts are necessarily limited to the use of bare fundamentals and trial-and-error tests. Obviously, the most direct method of preventing their formation would be to limit the concentrations of the reacting chemicals in the boiler water, but such a procedure is not always economically feasible. However, it does seem logical to limit the amount of any reactant added to the boiler water to that specifically required.

For example, directly involved in the formation of potassium-aluminum-silicate scale is the concentration of each constituent in the boiler water; indirectly involved are the ionic concentrations of all other chemicals present. In general, the operator is forced to accept small amounts of aluminum and silica in in the boiler water; without special equipment for their removal from the feedwater, control measures are usually limited to combating condenser leakage and evaporator carry-over and resorting to boiler blowdown.

However, potassium, the major constituent, is deliberately added to the boiler water. By co-ordinated-pH control, the amount of such additions is held at a minimum; in addition, as ionic association takes place in the concentrating film, it is apparent that these conditions will limit the ionic concentration of potassium, thus tending to stifle the formation of such scales. This follows from consideration of the role of the reactants in the equilibrium expressed by the solubility-product equation. The addition of potassium chloride for maintenance of certain ionic ratios or to minimize caustic attack of tubes is contrary to these principles of scale prevention.

AUTHORS' CLOSURE

The discussion by Messrs. Purcell and Whirl presents their interpretation of the data that were given to explain the benefits derived at Springdale with potassium treatment in preventing silica scale, and chloride treatment to prevent attack on the boiler metal by the concentrating-film boiler water. Their conclusions seem to be based on an endeavor to prove that boiler-water conditions were maintained within the limits they have set for co-ordinated phosphate-pH control. The pH analysis as given in Table 10 of the paper was used for this purpose.

The discussers conclude that the addition of chloride for preventing oxide development is secondary to the reduction in alkalinity to a level corresponding to co-ordinated phosphate-pH control (no free caustic present).

The data presented do not justify this conclusion.

It is a moot question whether the routine pH-value determination of highly alkaline boiler waters is more or less accurate than the hydroxides, as determined by the phenolphthalein end point in the presence of $BaCl_2$ (B reading). A study of many analyses made over a period of years definitely indicates more accuracy for the hydroxide analyses. The pH value is usually low. Referring to Table 10, the 0.8-epm B reading, even when diminished by 0.23 equivalent of K_2SiO_3, which might titrate, would amount to about 32 ppm KOH. It will also be noted that, in the other boiler-water analyses listed in the paper covering periods of chloride feed, the B readings, and hence free caustic, were considerably higher than in the analysis of Table 10. Thus, since free-caustic alkalinity definitely was present, the reduction of iron-oxide deposition cannot be attributed to co-ordinated phosphate-pH control as the latter condition did not exist.

The discussers refer to the use of chlorides as "antiboil" substances as contrasted with antifreeze compounds used in automobile radiators. This interpretation concludes that neutral salts (chlorides) are added to prevent boiling just as alcohol is added to an automobile radiator to prevent freezing. The soluble chlorides are not added to the boiler water to prevent boiling. Rather they become valuable only as a result of boiling, when their resultant concentration in the concentrating-film boiler water exerts an inhibiting effect on caustic corrosion. The purpose in adding soluble chlorides is to control the composition of the concentrating-film boiler water and not the temperature at which it boils. The term "antiboil" as applied to the addition of neutral salts is inexact and likely to promote confusion.

In the discussers' comments on silica deposits, there are several statements purporting to represent Hall's views on silica deposition and instability of potassium-silicate solutions under boiler conditions when the ratio of SiO_2/K_2O is greater than 1.6. Reference to Morey's data[7] and Hall's paper[6] will show that these statements are unwarranted. Instability occurs only when solubility is exceeded, and both potassium metasilicates ($SiO_2/K_2O = 1$) and disilicates, ($SiO_2/K_2O = 2$) increasing in solubility with temperature, have large values of Δt_s at moderately high and higher pressures. Thus, in high-pressure boilers, such as at Springdale, precipitation would not occur.

To quote Hall," . . . and at the pressures above 225 psia, and at ratios of silica to alkali in the range of 2 or less there is practically no possibility of deposition of silica or the potassium-silicate compounds in the concentrating-film boiler water for any values of the Δt function within the range of reason. The interesting point is, that the higher the operating pressure of the boiler, the more certainly this is the fact." From this it follows that the selection of the K_2SiO_3 ($SiO_2/K_2O = 1$) pH curve as the

control guide will provide considerably more alkalinity than necessary to prevent precipitation of silica or potassium-silicate breakdown products in the boiler proper. In the sodium system, these facts will, of course, not be applicable.

To summarize, published and unpublished data representing many analyses do not agree with the discussers that the benefits noted in the paper accrued from the maintenance of boiler-water alkalinity as captive alkalinity of the reserve phosphate. They do indicate that the improvement in the concentrating-film boiler water was derived from the presence therein of appreciable chloride.

L. E. HANKISON.[8]
M. D. BAKER.[9]

[8] Superintendent, Efficiency Department, West Penn Power Company, Pittsburgh, Pa. Mem. A.S.M.E.

[9] Chief Chemist, West Penn Power Company, Springdale, Pa.

Air-Brake Developments

COMMENT BY C. D. YOUNG[10]

This paper[11] gives an excellent review of the historical background of development and changes in the art of braking equipment designed to control freight trains.

For economic reasons there appeared in the period preceding this war hopper cars of 90 to 120 tons capacity. Braking such cars presented new problems.

The mechanical officers of the railroads, in co-operation with the supply industry, met these problems of the larger cars with applications of brakes in a variety of ways and out of that experience undoubtedly the air-brake companies will evolve, to the point of commercial application, the load-compensating brake equipment. These initial applications have indicated the value of the desirable features found in this new brake and may meet requirements for certain postwar cars, the lightweight of which will be substantially less for the same carrying capacity than of those in the period preceding this war.

Increased speeds for freight trains have followed from the demand for fast-freight service, resulting from the endeavor of the railroads to meet the competition of over-the-road trucks. Here again, on lightweight "house" cars, the compensating brake undoubtedly has attractive possibilities for postwar use.

In Table 1, the author points out the effect of the use of lightweight materials in car construction and indicates that, for a car having a lightweight of 30,000 lb, the ratio of gross to tare will be almost 6 to 1. There is therefore a distinct need for an improved brake, if such cars are to be handled safely. He indicates that a percentage of 33 can be provided. On the other hand, with a freight car of 50,000 lb lightweight and a gross-to-tare ratio of 3.4 to 1, the load-braking ratio would be 50 per cent. It is not clear why 33 per cent is suggested in the case of the light car as compared with the heavier vehicle, except it is readily apparent that, to have the load-braking ratio uniform on the lighter vehicles, it will be necessary to restudy the foundation brake rigging and the application on the freight cars. It would seem appropriate that such study should be initiated before any final determination as to the most desirable load-brake ratio. The suggestion is made that this factor might be studied by the Mechanical Division of the Association of American Railroads.

The paper also gives considerable detail on the application of the load-compensating brake to the locomotive. The writer does not care to express any opinion on this phase of the problem until some definite decision is reached as to the character of the brake and brake rigging which will be applied to lightweight freight cars. The logical procedure would be to fix upon the accepted practice for lightweight freight cars before attempting to determine the character of equipment to be used on the engine and tender. This suggestion, of course, does not preclude experimental applications to locomotives, particularly those which have large tenders with a wide variation in gross-to-tare weight between the tender when fully loaded with fuel and water, as compared with the tender when empty.

The writer wishes to stress the pressing need at the present time and the still more pressing need in the near future for development of brakes to lightweight equipment which will be built with greater use of corrosion-resistant light metals. Furthermore, tests of the improved brake should be made without delay to advance knowledge of the merits of this particular design, functioning as it does as a part of and supplementing the present AB brake.

AUTHOR'S CLOSURE

Mr. Young's remarks summarize very nicely the problems associated with the adequate braking of lightweight freight cars. His comments with respect to the braking ratio of the loaded car are particularly pertinent. The maximum permissible ratio and maximum leverage ratio and the minimum and maximum brake-cylinder piston travels are all covered by A.A.R. rulings, and it would therefore be very desirable to have an appropriate committee assigned to the study of any change or changes that may be required in any one of these three established practices.

C. D. STEWART.[12]

[10] Deputy Director, Office of Defense Transportation, Washington, D. C. Fellow, A.S.M.E.

[11] "Load-Compensating Air Brakes," by C. D. Stewart, MECHANICAL ENGINEERING, vol. 67, 1945, pp. 511–514.

[12] Vice-President, Westinghouse Air Brake Company, Pittsburgh, Pa. Mem. A.S.M.E.

Supercharged Diesel Engines

COMMENT BY CARL HARMS[13]

It is believed that the matter of cooling manifolds, referred to in this paper,[14] was probably brought about by the manufacturers placing a definite limit on the turbine temperatures. By using cooled manifolds in one form or another, higher ratings were gained from the engine or were developed by the engine without exceeding the predetermined temperature limits of the turbine.

COMMENT BY HANS BOHUSLAV[15]

The writer would like to ask the author whether or not tests have been made with the fully cooled exhaust manifold and what was the percentage increase in heat rejection. He believes the fully cooled manifold would be helpful in many respects, particularly from the standpoint of improvement in design and appearance of the engine, which in turn is more or less an indication of simplified assembly, manufacture, and subsequent maintenance.

A point has been brought up which the writer believes should be emphasized. The temperature of the turbine is usually the limiting factor in the maximum output of an engine. There also are other

[13] Elliott Company, Jeannette, Pa.

[14] "Design Aspects of Supercharged Diesel Engines," by R. L. Boyer, MECHANICAL ENGINEERING, vol. 67, 1945, pp. 392–397.

[15] Vice-President in Charge of Engineering, Sterling Engine Company, Buffalo, N. Y. Mem. A.S.M.E.

things that may limit the output of an engine, but in the final analysis these other factors can be improved whereas the temperature of the turbine is definitely a limiting point at the present time.

There still is another angle to that, i.e., at a given engine load where the maximum safe turbine temperature is not exceeded, it is advisable to keep the temperature of the turbine as low as compatible with efficient and proper performance, and for that reason it is believed quite important to find out just how much exhaust-gas cooling is possible, and how much the capacity of coolers and radiators must be increased to accomplish that.

Comment by Ralph H. Miller[16]

The heat dissipation or total heat flow to the water jackets is obviously proportional to the internal surface temperatures and, on the basis of equal internal temperature and heat stresses, the correct load for a supercharged engine is that at which the total heat flow to the water jackets equals the heat flow of the same nonsupercharged engine at its normal rated load.

Accurately conducted heat-balance tests show that, when supercharging with the Buchi system, this load is about 27 and 31 per cent above the nonsupercharged load for a 600- and 360-rpm engine, respectively.

At 42.5 per cent increase in horsepower as used in the author's Table 1, the heat flows for these same engines show an increase of 18 per cent where the author finds it to be 5.85 per cent. His reference to radiator equipment indicates that the heat flow of 2482 Btu per hp-hr includes a water-cooled exhaust manifold.

In a modern well-designed engine the Btu per hp-hr includes 7 to 8 per cent of the total heat removed by the piston cooling oil but exclusive of exhaust manifold should not exceed 1700 with the jacket-water mean temperature at 155 F.

A comparison of the heat flow of a nonsupercharged engine, including the heat rejected from the exhaust manifold with the heat flow of a supercharged engine with non-water-cooled exhaust pipes is obviously of no value except to determine radiator equipment.

The heat rejection to the engine jackets of an atmospheric engine is between 15 and 16 per cent of the total heat supplied, and to the water-cooled exhaust manifold between 7 and 8 per cent.

Table 1, herewith, shows the breakdown of the heat rejection to the cooling water in a 600-rpm 12-in. × 14-in. Buchi supercharged engine equipped with water-cooled "Helixaust" pipe at loads of 120 and 132 bmep.

The atmospheric engine of the same bore and stroke has a heat rejection to the water jackets of 12,000 Btu per min, operating at 80 bmep. Heat rejection to piston cooling is 4800 and to the water-cooled exhaust manifold 5200 Btu per min.

If limited to a jacket-water heat flow of 12,000 Btu per min, the Buchi supercharged engine will carry only 102 bmep. However, if the inlet manifold air is cooled to 90 F, the supercharged engine will carry 124 bmep in a heat flow of 12,000 Btu per min. These tests have shown that supercharging without cooling the air is of small real value if engines are rated on the basis of equal cylinder pressures and internal temperatures, as they should be.

TABLE 1 HEAT REJECTION TO COOLING WATER IN 600-RPM 12-IN. × 14-IN. BUCHI SUPERCHARGED ENGINE

Engine, bhp	864	950
Bmep, psi	120	132
Ambient temperature, F	90	90
Air temperature manifold, F	140	145
Heat to engine jacket cooling water, Btu per min	14500	16500
Heat to exhaust-manifold cooling water, Btu per min	8900	9000
Heat to exhaust-gas turbine cooling water, Btu per min	2500	2600
Heat to water-cooled turbine-inlet connection, Btu per min	890	900

Comment by Charles E. Beck[17]

This paper is particularly interesting and timely because so many companies are now building supercharged engines for the Armed Services and for commercial applications.

The author states that the supercharged engine is more economical than the nonsupercharged type and gives the amount as approximately 5 per cent. It would be interesting to know if this gain is all attributed to improved scavenging or to higher firing pressure, or both. What are the author's ideas on this? Is there any indication as to how much of the improved economy would be credited to improved scavenging and how much to higher initial pressure. Also, at what load was the 5 per cent better economy noticed? It is generally understood that at light loads the improvement in economy is even much better than at full load. Did the author notice this in any of his observations and does he have any figures?

The matter of water-cooling exhaust manifolds is receiving a lot of attention because users are complaining of excessively hot engine rooms and of operators getting burned while working around an engine. This is being alleviated by the adoption of water-cooled "Helixaust" headers. In this design of header, spiral chambers running lengthwise of the header separate the individual engine exhausts so that they enter the supercharger without overlapping. This header has an outer cooling water jacket and an inner cooling member that consists of a central pipe running the length of the header. Tests with and without the cooled header indicate that a turbocharger selected for use with the uncooled header has ample capacity to carry engine rating when operated with the cooled header. The only noticeable change in the engine using cooled headers was a slight slowing down of the turbocharger impeller. This was due of course to somewhat cooler exhaust gas moving at less velocity.

Author's Closure

The author appreciates the comments of the various discussers. Mr. Bohuslav is interested in knowing the amount of increase in the heat rejection as compared to the so-called water-blanketed exhaust. We are glad to be able to report test data (Table 2), taken from the logs of one of our 8-cylinder Diesel engines which was tested with both types of manifold.

TABLE 2 TEST DATA FROM LOG OF 8-CYLINDER DIESEL ENGINE

	Blanketed	Jacketed
Fuel rate, lb per hp per hr	0.38	0.389
Turbine inlet temperature, deg F	1010	810
Turbine, rpm	18000	16000
Exhaust color	1.5	2.0
Total heat to water, Btu per bhp-hr	1505	1855

It will be noted from Table 2, that the total heat rejection to the engine was increased by more than 23 per cent. While unquestionably it is good for the turbine to cool the exhaust, this quite evidently is not in the direction of best performance for an engine. The most serious thing, however, is the high heat rejection with the cooled exhaust, because of its effect on heat-dissipating equipment such as radiators, heat exchangers, etc.

The author cannot agree with Mr. Miller in his statement that the correct load for the supercharged engine is that at which the total heat flow to the water jackets equals the heat flow of the nonsupercharged engine at its normal rated load. It certainly has not been general experience that the rate of heat flow to the water jackets of an engine is the limiting factor in the engine's rating. In so far as the author knows no damage has

[16] Chief Engineer, Worthington Pump & Machinery Corporation, Buffalo, N. Y. Mem. A.S.M.E.

[17] Sales Engineer, Busch-Sulzer Diesel Engine Company, St. Louis, Mo. Mem. A.S.M.E.

resulted where the heat flow has even been doubled. The limit in rating of an engine is that of combustion and of exhaust valves, for example, and has never been the rate of heat flow, except possibly to pistons which have in recent years been sufficiently cooled so that even they are no longer the limiting factor.

The author therefore sees no reason for not increasing the rating of a supercharged engine to the point where combustion or turbine temperatures become the limitation.

As to the variations between the author's observations and those of Mr. Miller, similar variations have been found among engines of even one make, or even on any one design of engine. The author has never been able to quote figures quite so definitely as indicated by Mr. Miller, because of variation in test results, and the figures given in the paper are averages of several engines on several different tests. As to the statement about heat rejection at a definite jacket-water mean temperature, the author has never found jacket-water mean temperature to be an important factor in the amount of heat rejection.

Mr. Miller states that the comparison of heat rejection between an atmospheric engine with an exhaust manifold and that of a supercharged engine with a non-cooled manifold is of no value, except to determine radiator equipment. That is of course exactly why the author made the comparison, as radiator equipment, when speaking in terms of 23 per cent, becomes extremely important. It is almost equally true where jacket-water heat exchangers are used, as they are nearly as expensive as radiator equipment.

Furthermore, on locomotives, draglines, etc., the size of radiators is extremely important irrespective of their cost.

Mr. Beck inquired as to whether in the opinion of the author the improved fuel economy of a supercharged engine was due to improved scavenging, or possibly higher cylinder pressures. It is believed that both of these are factors, but a more important factor is that we are simply taking more horsepower from a given size of engine. It is quite obvious that the friction factor is a lower percentage in the case of a supercharged engine than an atmospheric engine.

Mr. Beck then inquired as to whether a supercharged engine was relatively still more efficient at light loads. That is true if one considers the same percentage of load in each case, thereby meaning a higher mean effective pressure at any given load for a supercharged engine. However, if one considers it in terms of bmep, then the two types of engines are about equal in fuel rate at any given bmep. Considering a given horsepower, whether it is to be turned out by an atmospheric engine or a supercharged engine, then the supercharged engine is more economical at all loads.

R. L. BOYER.[18]

[18] Chief Engineer, The Cooper-Bessemer Corporation, Mt. Vernon, Ohio.

Radial Rake Angles in Face Milling

COMMENT BY FRED W. LUCHT[19]

This paper[20] is of particular value to the writer since we have been greatly interested in the use of the double radial rake angles while face-milling steel. We have found when the face of the carbide blank is set at a 12-deg positive radial rake angle and at a 10-deg negative axial rake angle, as shown in Fig. 1 of this comment, it simplifies the grinding of a 10-deg negative radial rake angle which is widely used on cutters for milling heat-treated alloy steel. It also permits a rapid reduction of the 10-deg negative radial rake angle to 5 deg negative, to zero degrees, or even to a slightly positive radial rake angle by a simple grinding operation when it is necessary to mill softer steels.

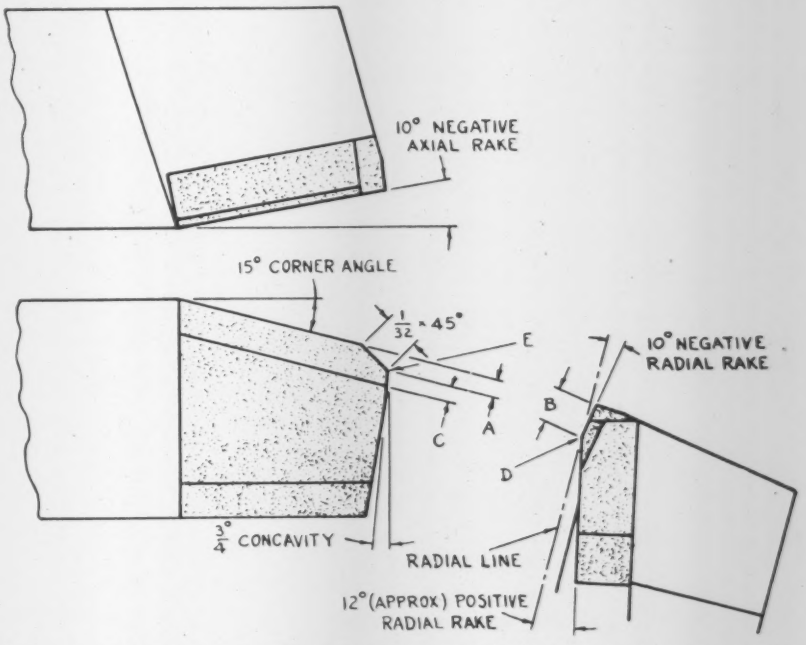


FIG. 1 FACE OF CARBIDE BLANK SET AT 12 DEG POSITIVE RADIAL RAKE ANGLE AND 10 DEG NEGATIVE AXIAL RAKE ANGLE

We have done a large amount of work face-milling steel with the rake angles mentioned and with a tooth profile ground to a 15-deg corner angle, a $^3/_4$-deg concavity angle, and a $^1/_{32} \times 45$-deg chamfer. We have also found that if the chamfer is much wider than $^1/_{32}$, an increased impact develops which tends to shorten the cutter life.

When the chamfer is $^1/_{32} \times 45$ deg, the distance A is equal to 0.016. There are indications that when the width B for the 10-deg negative radial rake surface is less than or equal to 0.016, the cutter life is somewhat erratic when milling steels which have an increased hardness.

When the width B is less than 0.016, this is probably due to the fact that there is a tendency to warp the chip because the chamfer near the corner angle has a negative radial rake while the chamfer near the face of the cutter has a positive radial rake angle.

When the width B is equal to 0.016, the distance C becomes zero and the point D coincides with E. With such a set of conditions, it is difficult to grind a multitooth cutter so that its face will run true with 0.0003. This is due to slight variations which creep in o the cutter-sharpening operation on the cutter grinder, making it impossible to obtain an absolute matching of the chamfer corner E, and the line of intersection D at the face of the cutter.

A few preliminary runs have actually indicated that the longest cutter life was obtained when the width B of 10 deg negative-radial-rake portion was

[19] Development Engineer, Carboloy Company, Inc., Detroit, Mich. Mem. A.S.M.E.

[20] "Radial Rake Angles in Face Milling," by J. B. Armitage and A. O. Schmidt, MECHANICAL ENGINEERING, vol. 67, 1945, pp. 403–406, 453–456; 507–510.

about 0.045 when using 0.0126 feed per tooth and 500 fpm. This makes the dimension $C = 0.029$. This distance C is enough to cover the normal wear which might develop along the face of the cutter while it is in operation. This also carries the point of intersection D a sufficient distance C below the chamfer where slight variations in grinding will not cause any trouble. We used a width B which was even greater than 0.045 and have been able to obtain consistent runs with the width $B = 0.065$ to 0.100, and the cutters have stood up well under bad operating conditions.

With this thought in mind, we are interested in knowing if the authors have found whether there is any relationship between the size of chamfer and the width of the negative-radial-rake portion on the face of a tooth. It happens to be one of those minor details which can easily become a major item. It is worth some serious thought.

AUTHORS' CLOSURE

Mr. Lucht has raised an important point regarding the width B on the face of the milling-cutter tooth and the size of the chamfer. If the chamfer is wider than B and thus extends into the positive rake section of the tooth the strengthening effect of the negative rake angle in this particular place is lost. Since this corner is especially vulnerable in face-milling cutters the cutter life will be very noticeably reduced if too large a chamfer is ground. The chamfer must always be ground on the negative radial rake section of the corner of the tooth. However, the top view in Mr. Lucht's sketch indicates a chamfer extending up to the positive radial rake section which is very detrimental to tool life.

J. B. ARMITAGE.[21]
A. O. SCHMIDT.[22]

[21] Vice-President in charge of Engineering, Kearney & Trecker Corporation, Milwaukee, Wis. Mem. A.S.M.E.

[22] Research Engineer in charge of Metal Cutting Research, Kearney & Trecker Corporation, Milwaukee, Wis. Mem. A.S.M.E.

Less Mud in the Water

TO THE EDITOR:

The issue of September, 1945, of MECHANICAL ENGINEERING carries a very interesting letter (page 613) entitled "More Mud in the Water," which brings out several points that call for comment.

The writer is to be congratulated on having had a very fine idea twenty-five years ago. We quote from his letter:

"Twenty-five years ago I sat in a conference with the chief engineer of our company and the general foreman of the machine shop to settle this problem once and for all. It seemed like such a simple matter at the time. We expected to get out some sample blocks, say, five or six, finished in differing degrees of roughness. One set was to be held in the drafting room so that the designers could select the finish desired, and other sets were to be placed in the shop so that the machinists would have no difficulty producing what was required. Each block was to bear a number, and the draftsmen were to be instructed to discontinue the old familiar f and in its place use a triangle or a V with its vertex touching the line of finish. Inside the symbol was to appear the number of the finish desired.

"Satisfied with this simple device, we turned over to the foreman the task of making a set of samples."

It is regrettable that he did not pursue the matter to a finish which is apparently what a large manufacturing concern, mentioned in his letter, has done under the drive of necessity.

Apparently, his basic idea was to find a simple method of instructing the machine shop as to exactly the type of finish the designer contemplated.

The problem today is somewhat broader in that in addition to having the shop understand clearly what type of finish the designer contemplates, it is also necessary to convey the same information to the customer's engineer and inspector so that friction in the shop between the shop personnel and the customers may be held to a minimum.

The ..... Company's descriptive literature regarding Roughness Specimens says, in part:

"Standard Roughness Specimens illustrate degrees of roughness. They provide a simple and practical method for specifying, producing, and inspecting product surfaces, and establish a mutual understanding of surface roughness requirements between apparatus design and production personnel.

"These specimens illustrate machined surfaces and represent degrees of roughness commonly encountered in surface processing, rather than specific methods of processing. There are many processes by which each degree of roughness can be obtained.

"The design engineer or draftsman elects a specific roughness needed for a surface from a set of standard roughness specimens and indicates his selection on a drawing using the appropriate symbol. In this way he has an actual sample of what the finished surface will be.

"The inspector can then inspect the finished-product surfaces by comparing them with the proper specimen.

"When making comparisons with the standard roughness specimens, it is important that the comparison be made with the surface whose lay most nearly resembles the work surface. Generally, comparisons are made by sight and feel methods. By running the fingernail or tip of the finger over the work surface and over a standard specimen, the degree of roughness can be determined. Regardless of the material or method of processing used on the finished product, each specimen represents the roughest surface acceptable for each symbol."

"Microinches or Electronics:" A knowledge of microinches or electronics is not essential to anyone using this tool. It is of interest to note that there is a total of ten (10) symbols, the most complicated being $\sqrt{6\frac{1}{2}}$.

It is worth bearing in mind that a drawing, if one disregards the wording, notes, and titles, is the most universal language that exists in the world of today, and that one of the limitations of the universal understanding of the drawings is that to date no universally accepted symbol for properly specifying the machine finish contemplated by the design has been established.

With this tool, as with each new tool, there is danger of misapplication. If the selection of the design finish is left to the man responsible for the design, this tool should be of great service to everyone. However, should the purchaser's engineers try to select finishes and include such selections in the contract specifications generally, this tool may cause a great deal of aggravation and annoyance, and possibly real trouble. There may be exceptional cases where the purchaser's engineer, because of special background and experience, is in a better position than the manufacturer to specify a design finish. These cases will be rare, and the purchaser's engineer should have no difficulty in selling his idea to the manufacturer.

Your correspondent's letter makes it appear that the writer of the preamble to the "Tentative Standards" referred to did not do a good selling job. (Incidentally, I have not seen the "Tentative Standards" mentioned.)

From a careful study of your correspondent's letter and the descriptive literature available to me at the moment, it would appear that he has now obtained exactly what he was looking for twenty-five years ago.

WILL M. H. BALLANTYNE.[23]

[23] Baltimore, Md.

A.S.M.E. BOILER CODE

Interpretations

THE Boiler Code Committee meets monthly for the purpose of considering communications relative to the Boiler Code. Anyone desiring information on the application of the Code may communicate with the Committee Secretary, 29 West 39th Street, New York 18, N. Y.

The procedure of the Committee in handling the cases is as follows: All inquiries must be in written form before they are accepted for consideration. Copies are then sent by the Secretary of the Committee to all members of the Committee. The interpretation, in the form of a reply, is then prepared by the Committee and is passed upon at a regular meeting.

This interpretation is later submitted to the Council of The American Society of Mechanical Engineers for approval after which it is issued to the inquirer and then published in MECHANICAL ENGINEERING.

Following is a record of the interpretations of this Committee formulated at the meeting of September 14, 1945, and approved by the A.S.M.E. Council on October 12, 1945.

CASE NO. 1023

(Interpretation of Pars. U-91 to U-96)

Inquiry: Is it permissible, under the Code, to fabricate unfired pressure vessels of copper conforming to Specification SB-11, if the main seams are lap-brazed in accordance with Pars. U-94 to U-96?

Reply: It is the opinion of the Committee that copper plates conforming to Specification SB-11 may be used for the construction of unfired pressure vessels by lap-brazing under the general requirements of Pars. U-94 to U-96.

CASE NO. 1024

(Interpretation of Par. U-75)

Inquiry: Par. U-75 specifies that dished heads shall have a flange. Was it intended that full hemispherical heads, designed for attachment by butt welding, shall have a flange (skirt)?

Reply: In the opinion of the Committee it is not the intent of Par. U-75 to require an integral skirt (flange) on full hemispherical heads which are designed for attachment by butt-welding. Attention is called to the requirements of Par. U-72(*e*) for trimming the thicker plate, where plate edges of an unequal thickness are abutted.

Proposed Revisions and Addenda to Boiler Construction Code

IT IS the policy of the Boiler Code Committee to receive and consider as promptly as possible any desired revisions of the rules and its codes. Any suggestions for revisions or modifications that are approved by the Committee will be recommended for addenda to the code, to be included later in the proper place.

The following proposed revisions have been approved for publication as proposed addenda to the code. They are published below with the corresponding paragraph number to identify their location in the various sections of the code and are submitted for criticism and approval from anyone interested therein.

It is to be noted that a proposed revision of the code should not be considered final until formally adopted by the Council of the Society and issued as pink-colored addenda sheets. Added word are printed in SMALL CAPITALS; words to be deleted are enclosed in brackets [ ]. Communications should be addressed to the Secretary of the Boiler Code Committee, 29 West 39th St., New York 18, N.Y., in order that they may be presented to the Committee for consideration.

PAR. P-115. Add the following as (**b**):

(**b**) Vertical fire-tube boilers may be constructed by welding the Ogee bottom of the furnace sheet to the outside shell as shown in Fig. P-8$^1/_2$ provided that:

(1) The tube or crown sheet is fully supported by tubes, or braces, or both;

(2) The joint is wholly within the shell and forms no part thereof;

(3) The weld is not in contact with primary furnace gases;

(4) The throat of the full fillet weld is at least equal to 0.7 of the thickness of the furnace sheet;

(5) The maximum depth of the waterleg does not exceed 4 in. and the radius of the Ogee is not greater than the inside width of the waterleg.

(6) The pitch of the lower row of staybolts does not exceed one half the maximum allowable staybolt pitch measured from the center of the staybolt to the tangent of the Ogee; and

(7) The construction conforms in all other respects to Code requirements including welding, stress-relieving, etc., except that radiographing is not required.

PAR. L-108(*d*). Revise to read:

(**d**) Following the hammer test, the pressure shall be MAINTAINED AT [raised to] not less than ONE AND ONE-HALF TIMES [twice] the working pressure for a sufficient time to enable a complete inspection to be made of all joints and connections.

PAR. U-75. Add the following:

Dished heads of full hemispherical shape need not have an integral skirt (flange), but where a skirt (flange) is provided for butt-welded attachment it shall have at least the thickness required for an equivalent seamless shell.

Proposed Provisions for Use of Non-Code Materials

WITH the ending of the war, a considerable quantity of excellent quality steel plate material has suddenly become available to boiler and other pressure vessel manufacturers. Much of this material comes within the physical and chemical ranges of at least one approved Boiler Code specification, but lacks the proper credentials of identification. The Committee has received numerous requests for permission to use some of this plate material in Code constructions. As a result, the following interpretation has been prepared by the Committee after prolonged study of the question and is published for the purpose of soliciting comments from all interested parties. The proposed interpretation is *not* a final action of the Committee:

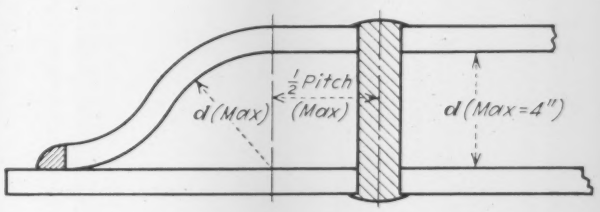


FIG. P-8$^1/_2$ WELDING OGEE RING

Inquiry: May plate material not identified as complying with an approved Code specification be used in the construction of boilers and unfired pressure vessels if it can be demonstrated either by presenting acceptable authentic test reports or by conducting chemical and physical tests that the material does have properties within the permissible range of an approved Code specification?

Reply: It is the opinion of the Committee that plate material not completely identified with any approved Code specifications may be used in the construction of boilers and unfired

pressure vessels under the following conditions:

(1) If an authentic test record for each plate in its present condition is available, proving it to have properties within the permissible range of an approved SA or SB specification.

(2) If an authentic test record is not available or there is no marking on the plate positively identifying it with an authentic test record, each plate shall be subjected to the chemical and physical tests required for that grade in the Code specifications[1] with which the plate is to be identified. The additional requirements given below in (*a*) and (*b*) shall also be satisfied:

(*a*) *Chemical Tests.* Check analysis shall be made from a tension test specimen cut from a corner of each plate. Drillings for these tests shall include the full thickness of the material.

If the corresponding specification is in the SA group and does not require the carbon and manganese contents, determinations of these elements shall be made and recorded. The decision as to whether or not the carbon and manganese contents are satisfactory shall be made by a qualified inspector and shall be acceptable to both fabricator and user.

(*b*) *Physical Tests.* When the direction of rolling is not definitely known, two tension test specimens shall be selected from a corner of each plate and at right angles to each other. One of these must yield the specified tensile strength. Similarly, two bend tests shall be made on specimens taken from the centers of adjacent sides of each plate. Both of these must meet the specification. Steel for which firebox quality is required shall also pass the homogeneity test required by the applicable specification.

(3) If the plate materials comply with either (1) or (2), the boiler or pressure vessel manufacturer or the testing agency shall stamp or otherwise mark as permitted by the applicable material specification, a serial "S" number on each plate, in the presence of the inspector.

(4) Suitable report forms, clearly marked as being a "Report on Tests of Non-Identified Material" shall be furnished by the boiler or pressure vessel manufacturer or testing agency, properly filled out, certified by the testing agency and approved by the inspector.

(5) The qualified inspector shall have the right to accept or reject the testing agency or the test results.

(6) The requirements for fabrication applicable to the specification to which the non-identified material corresponds shall be followed and the allowable design stress shall be that given in Tables U-2 (P-7) or U-3 for that corresponding specification.

[1] Until the several SA specifications can be revised to permit harmless amounts of the residual or tramp elements, the following tolerances are suggested as a conservative guide:

Carbon-silicon steel plate to be fabricated by welding, containing residual chromium and/or molybdenum should have the sum of manganese plus chromium plus molybdenum content no greater than the specified maximum for manganese, when the carbon is not more than 0.35 per cent. This would limit the hardenability of the material to approximately normal expectancy. The effect of residual nickel and copper is much less than that of chromium and molybdenum, but for weldable steels the copper should not exceed 0.30 per cent.

REVIEWS OF BOOKS

And Notes on Books Received in the Engineering Societies Library

Job Placement Reference

JOB PLACEMENT REFERENCE, With Introduction to the Job Placement Technique. By Keith Van Allyn. National Institute of Vocational Research, Inc., Los Angeles, Calif., 1945. Cloth, $8^1/_4 \times 10^1/_2$ in., 361 pp., $10.

REVIEWED BY DONALD E. GORSELINE[1]

THIS book is the explanatory manual for the Van Allyn Job Placement Technique which is an attempt to coordinate testing procedures and job specifications to provide a convenient method of comparing individual qualifications with occupational requirements. The technique is expected to prove valuable to: (*a*) high-school and college vocational counselors, (*b*) employers and personnel managers, (*c*) rehabilitation directors of war-veteran or civilian institutions.

The method of using the technique is as follows: First, the applicant to be placed or counseled is given the job-qualification inventory, an ingeniously contrived, easily scored, self-rating scale consisting of a series of 6 question sets in each of 35 occupational areas, said to represent the entire range of human knowledge and endeavor. Each set of questions investigates interest and ambition as well as training and experience, and is uniquely designed to prove the expressed interest or accomplishment. Next, the scale is scored and a typical graphic profile of the proficiency in the 35 occupational areas is inked on the cover chart. Last, analysis is begun by ascertaining those areas of greatest interest and proficiency, combining them into a coded letter pattern for the individual, and looking up his pattern in an encyclopedia of occupations whose requirements are expressed in terms of the same basic elements. The patterns in the encyclopedia are classified in such manner as to make them easily accessible.

Many advantages are claimed for the system, among which are the following:

1 Interviewing time is reduced.

2 Placement is made according to real interest and ability.

3 Many malcontents, especially those caused by vocational misplacement, are detected in advance. However, those unstable from physical or inherited causes must be screened more by the expertness of the clinical interviewers than by the inventory itself.

4 Training weaknesses are diagnosed in advance.

5 The hazards of overoptimism or understatement or false statements about qualifications are minimized.

6 The United States Employment Service and the United States Civil Service Disability Codes are provided for each occupation for the convenience of agencies desiring to use them.

7 Transfers, promotions, downgrading, exit interviewing, war-veteran reemployment, manpower surveying, etc. are facilitated.

Evaluation of the book and the technique involves the following criticisms. In the first place, the author does not give a clear-cut outline of the procedure he used in selecting, testing, and validating the contents used in the job-qualification inventory, a practice which is common procedure with most rating-scale or test builders. One has a right to ask, "Just why were the particular 35 areas of occupations used? Why not 25 areas, or 39 areas?" Likewise in the job-placement reference, the encyclopedia of jobs, what technique was used to determine the numbers and names of jobs listed on the 221 pages? Inclusion of two pages of simple description of the methods used to construct the materials used in the technique would have obviated the almost painful effort used to reassure the reader of the excellence of the system.

In the second place, the manual proba-

[1] Supervisor Training Staff, Training Department, Caterpillar Tractor Company, and Assistant Professor of Psychology, Bradley Polytechnic Institute, Peoria, Ill.

bly would have been improved by terse staccato sentences summarizing the methods of giving and scoring the job-qualification inventory and applying the findings.

This should have been done for the sake of custom, since test users expect instructions to be streamlined, if for no other reason.

Constructively, much can be said for the Van Allyn procedure. The reader cannot help but feel that in spite of the almost extravagant claims made for it, the author, backed by 12 years of research, can prove his statement that this represents an important forward step in the science of properly selecting, placing, and training employees. This reviewer, who tries to keep abreast of movement and devices in the counseling field, can think of no other test or rating device that so skillfully extracts so much reliable information about interests and experiences of individuals in so brief a time. The method used to avoid falsification about qualifications of applicants is excellent, too.

While the technique will be more useful to a personnel worker clinically trained in psychology than to an inexperienced counselor, yet it is simple enough to be applied by the average industrial employer. An added point in its favor is the fact that it probably has better predictive value for adults and older people; a group often neglected by test builders in the past.

This reviewer is inclined to the opinion that this technique will have wide usage in industry. Unquestionably there is no other tool available that will give so much information on so wide a variety of industrial personnel problems; particularly re-employment and placement of war veterans, upgrading, downgrading, employment terminations, transfer and promotion requests, apprentice and training selection, prescreening of potential malcontents, proper placement, etc. as this one does.

While it is by no means a panacea for all employment selection, it should prove to be a distinctly useful tool.

Air Compressors

AIR COMPRESSORS (THEIR INSTALLATION, OPERATION AND MAINTENANCE). By Eugene W. Feller. McGraw-Hill Book Co., Inc., New York, N. Y., 1944. Cloth, 5¼ × 8¼ in., 460 pp., 414 figs., $4.50.

REVIEWED BY RALPH M. WATSON[2]

THE author of this book on air compressors has followed closely his stated purpose—to produce a book intended primarily for the operating engineer and the mechanical-engineering student interested in air compressors and compressed air.

The book summarizes the latest information available on operating and maintenance practice, gained apparently from manufacturers' literature, articles in trade journals, and practical operating engineers. Many excellent illustrations help to clarify the text of the book, which clarity, however, is somewhat offset by the placing frequently of the illustration several pages removed from the text without any cross reference other than the figure or table number in the text.

The book appears to have been hurried in its writing, so that many careless and loosely worded, and even contradictory, statements are made. This is unfortunate, as carefully worded statements are particularly important in any book written for the very reader to whom this book would be most valuable.

As an example, under "Effect of Altitude," page 60, the first two paragraphs read as follows:

> When the rarefied air at an altitude is compressed, slightly less power is required than when compressing the same volume of free air at sea level. This is because the air is less dense, or a smaller weight of air is being compressed but at a lower intake pressure and therefore through a greater number of compressions.
>
> If it were not for the fact that as the altitude increases, the ratio of compression also increases for the same discharge pressure, the horsepower required would fall as the altitude increased. Actually, the horsepower at altitudes is slightly greater because of the increase in compression ratio.

These are confusing to say the least.

On page 409, referring to Equation [16] ($PV = W53.3T$), the following statements are made:

> This important equation may be used to solve the many problems found in compressor operation that involve steady-state conditions of the pressure, volume, and temperature where PV = a constant.
>
> Equations involving changing conditions that occur during the actual expansion or compression of air, where the pressure, volume, and temperature vary during the process, require the use of an exponent PV^n = a constant. The exponent n is the ratio of specific heats $\frac{C_p}{C_v} = n = \frac{0.2375}{0.1689} = 1.406$ for dry air.

The limitations, both implied and explicit, of the use of these equations are not correct; this is aside from the error which exists in the language chosen.

Similar carelessly worded expressions exist throughout the book, forcing the reader to be on guard constantly against full acceptance of all statements. The result is that proper understanding of the text requires a sound knowledge of theory and at least a reasonable familiarity with practice, if the reader is not, in many places, to be left confused or misled.

In spite of the many weaknesses in the presentation of the theory and explanations of performance based on the theory, the book should be of considerable value:

1 As a much needed complement to the usual textbooks on thermodynamics, giving the student an excellent summary, with illustrations, of the latest practice as of the date of publication.

2 To the maintenance engineer.

3 To the draftsman making his first contact with compressing machinery.

It is hoped that in any future edition, more careful editing will eliminate the inaccuracies and inconsistencies in this presentation of some very excellent material.

[2] Assistant to the Vice-President in Charge of Engineering, Worthington Pump & Machinery Corporation, Harrison, N. J. Mem. A.S.M.E.

Books Received in Library

BIBLIOGRAPHY ON CUTTING OF METALS 1864–1943, prepared by O. W. Boston. The American Society of Mechanical Engineers, New York, N. Y., 1945. Cloth, 5½ × 8½ in., 547 pp., $6.50. More than four thousand items are listed in this invaluable compilation for the machine-tool designer and user. The main list is chronological and covers the period from 1864 to 1943. There is an author index to the list and a subject index is so tabulated that for any particular cutting process the items referring to the various types of tools, to cutting fluids, speeds and feeds, chip formation, finish, and wear may be readily found.

CALCIUM METALLURGY AND TECHNOLOGY. (American Chemical Society Monograph 100.) By C. L. Mantell and C. Hardy. Reinhold Publishing Corporation, New York, N. Y., 1945. Cloth, 6 × 9¼ in., 148 pp., illus., diagrams, charts, tables, $3.50. The opening chapters cover the properties and production of calcium. Succeeding chapters describe the constitution, properties, and uses of the important alloys containing calcium and of calcium hydride and point out the particular value of calcium in these combinations. The uses of calcium in the petroleum industry and in the production of certain metal powders are also discussed.

HISTORY OF PHOTOGRAPHY. By J. M. Eder, translated by E. Epstean. Columbia University Press, New York, N. Y., 1945. Cloth, 6 × 9¼ in., 860 pp., tables, $10. This comprehensive historical treatise is a translation of the fourth edition, 1932, of the original German work and carries through the first quarter of the twentieth century. It begins with an examination of the rudimentary knowledge of light and its properties held by the ancient Greeks and Romans, and proceeds, century by century, through the discoveries and contributions of individuals from many nations. All of the special processes and applications within the period involved are included, and a separate chapter presents a survey of the important photographic journals, societies, and educational institutions.

A.S.M.E. NEWS

And Notes on Other Engineering Societies

Professional-Mindedness and the Young Engineer

What the Society and Its Members Can Do to Help

PROFESSIONAL mindedness is one of the essential qualities of a professional man. It is a feeling, a loyalty, a sense of belonging to a group, a quality that sometimes finds different expressions in the junior and the senior engineer. This difference, however, is not a fundamental one but seems to be the result of differences in age, experience, and wisdom.

When a professionally mature engineer contemplates the advantages of participation and membership in a professional society, he tends to consider with a true sense of value such aids to professional development as ready technical information, the rewarding associations and friendships that come from society contacts, and the stimulus to achievement that is born of the intercourse between keen, creative, engineering minds. From such a moment of thought he is likely to ask himself, "What can I do for my society and for the young engineer?"

When a young engineer on the other hand approaches the question of membership in a professional society, he is likely to ponder over the events of his recent experience and to reflect against the background of the struggle and sacrifice of his engineering education, the cost of membership, and the nature and validity of the professed returns. He would ask the question, "What will a professional society do for me?"

It seems to be the eternal nature of a young man to have a remarkable appreciation of immediate advantage; to manifest impatience with slow, even though steady, personal progress; "to take the cash and let the credit go;" and generally to underestimate those great intangible values, which to the mature and elder mind stand out obviously as the only true and eternal pillars of a sound professional basis.

In the cycle of coming and going which is the life breath of any virile organization, it seems apparent that the elder members must teach and the younger members learn, and that what the mature professional engineer wants most to give in service, the younger engineer wants most to receive. On such a felicitous exchange of knowledge does the technical proficiency of the nation depend.

Unfortunately not all mechanical-engineering graduates become junior members of the Society, nor do all junior members accept the privileges of full membership. The predominant reasons for this lack of interest in the Society and its activities seem to be, first, the few real benefits offered which can be immediately grasped by the young engineer and second, the failure to evaluate properly the great intangibles that are the rewards of participation.

Aid the Society Can Give to Young Engineers

The young engineering graduate knocking on the door of industry or the young engineer groping for a happier outlet for his talents believes he should have the following aids from his professional society:

(1) A prestige of some definite value in the eyes of his prospective employer that will help him get the kind of job he wants.

(2) Help and consideration from members of the Society that will direct him into the channels of his choice or those favorable to his talents.

(3) A foundation for some assurance that the Society is able and willing to assist him in making his personal adjustments to a professional world.

These are all highly personal benefits that almost every engineer, at one time or another, desires and requires for his professional development.

Intensification of Programs

Now that the war is over and facilities of all kinds are again available, it is within the means of all professional societies to intensify their programs for the benefit of the student and junior membership. Such an intensification could take no better turn than to place emphasis on service and assistance to the young engineer and thereby dispel the false notion sometimes expressed among younger men that, in professional societies generally, the center of interest finds its natural habitat on the peaks of high professional attainment where there is little concern for the ambitions of aspiring young men.

The American Society of Mechanical Engineers has always maintained a lively interest in student and junior members, and in laying out a revised program greater consideration might be given to the following features:

(1) Staff visits to student branches frequently enough to be in close touch with each new generation of engineers.

(2) An active correspondence between the Society and the student branches.

(3) A monthly bulletin covering professional news from the student point of view as well as including adequate coverage of student-branch news.

(4) A policy of following-up on new junior members after they enter industry in order to demonstrate in a real way an interest in their welfare.

(5) A policy of encouraging students and junior members to look to the Society for help and advice.

(6) A policy of encouraging members who are also employers to investigate the available talent in the arena of Society membership when adding to their staffs.

A program intensifying these features would afford a convincing demonstration of the Society's interest and ability in directing the young engineer into his chosen channel in industry or, if he has no strong preferences, into the channels where his talents could be used to the best advantage.

From the campus point of view intensification of such a program—for most of these policies are in effect—would confirm the Society's professions of interest. The student member would be able to know through the Society representative the warm and friendly interest among the older members of the profession for him and his fellow engineers. The monthly bulletin specially written for him would give him the impetus toward professional thinking and keep him informed on the activities of his fellows. Should he have occasion to turn to the Society for advice, the experience of such a warm and fruitful contact would not be long in making the rounds of the campus, and before he became a junior member, he would be convinced that the Society represents a body of men like himself, men who have already surmounted the professional crises which are part and parcel of most men's lives and which he may feel he would inevitably encounter. If at this point in his development he should feel the need to associate himself with a group of such men, there would already exist for this student member the basis for sound professional development.

Such a basis, however is not a constant thing, but one that needs care and encouragement for its sustenance. It may deteriorate rapidly in the competitive atmosphere of the shop or office, where the new junior member encounters the habits of an unacademic way of life and where he may for the first time experience the enervating factors of a routine job. Under such circumstances the goal he set for himself could probably recede to such a nebulous distance that he would despair of ever achieving professional attainment.

Just as in the world of music great voices are lost because the promise of great talent goes along unrecognized and therefore undeveloped, so in the world of engineering great engineering talents may be wasting for want of opportunity. To the nation, to industry, and to society in general, the recognition and the development of such promise should be the invaluable service rendered by the technical societies.

How A.S.M.E. Members Can Help

The program suggested for the development of professional-mindedness among young engineers envisages, therefore, the interest and co-operation of the active membership of the Society. Such co-operation could be expressed in several ways, for example:

(1) By demonstrating a personal interest in the junior member, Society members could

(*a*) Welcome him into his new place of employment

(*b*) Help him find living accommodations

(*c*) Help him become familiar with the new community

(*d*) Introduce him to his associates and potential friends.

(2) By assisting the junior professionally and financially, they could

(*a*) Encourage companies to offer small prizes to student and junior members for essays on general subjects of technical or national interest

(*b*) Establish annual scholarships giving one or more junior members opportunity for advanced study.

(3) By full and spirited participation in Junior Group programs, they could

(*a*) Suggest, voluntarily, programs and capable speakers for junior affairs

(*b*) Encourage personal inspection of their plants by junior members when such inspections are arranged for in advance for the benefit of individual or group parties.

(4) By giving priority consideration to the talent on the roster of Society membership when adding to their staffs, they could

(*a*) Register their needs for talent with the Society

(*b*) Direct talent of exceptional promise into organizations best qualified to give such talent adequate opportunity for expression.

In summary, professional-mindedness in a young engineer is the awareness of the nature of his interest and his talents. It is an awareness that must be created and then carefully tended until a happy adjustment has been made in the field of industry. The American Society of Mechanical Engineers as the instrument of the profession has the means and the talent, as well as the duty to the nation and to itself, for an effective program of professional development.—A.F.B.

Actions of A.S.M.E. Executive Committee

At a Meeting Held at Headquarters, Oct. 26, 1945

A MEETING of the Executive Committee of the Council of The American Society of Mechanical Engineers was held at Society headquarters, New York, N. Y., on Oct. 26, 1945. There were present Alex D. Bailey, chairman; R. F. Gagg, vice-chairman; Alton C. Chick, and D. W. R. Morgan, of the Committee; J. J. Swan (Finance), A. R. Mumford (Sections), J. H. Sengstaken (Professional Divisions), K. W. Jappe, treasurer, D. Robert Yarnall, president-elect, C. E. Davies, secretary, and Ernest Hartford, executive assistant secretary.

Machine Design Group

On recommendation of the Committee on Professional Divisions, authorization was voted of the establishment of a Machine Design Group with the following committee: J. F. Downie Smith, chairman; P. B. Graves, Colin Carmichael, L. F. Nenninger, and G. F. Nordenholt, members.

Graphical Symbols

On recommendation of the Standardization Committee, adoption was voted of the Proposed American Standard for Graphical Symbols for Electric Power and Control as a standard of the Society. The standard was transmitted to the American Standards Association for approval as an American Standard.

Gas Turbine Test Code

On recommendation of the Power Test Codes Committee, authorization was voted of the organization of PTC Committee No. 22 on Gas Turbines.

Smoke Density Determination

On recommendation of the Power Test Codes Committee adoption was voted of the 1945 edition of the Supplement on Instruments and Apparatus, Part 20, Smoke Density Determination, as a standard practice of the Society.

Awards

Approval was voted of the following awards:

Charles T. Main Award, to Jack Drandell, of Southern Methodist University, for his paper, "Engineering in the New South." Mr. Drandell is now with the Allis-Chalmers Manufacturing Co., Milwaukee, Wis. He is a junior member of the A.S.M.E.

Undergraduate Student Award, to John Waldemar Erickson, Ensign, U. S. Navy, formerly of the Illinois Institute of Technology, for his paper, "Increasing the Efficiency of Gas-Turbine Cycles." Ensign Erickson is now a junior member of the A.S.M.E.

Certificate of Award

Authorization was voted of a Certificate of Award for W. G. Humpton, a member of the Boiler Code Committee for ten years, who resigned because of ill-health.

Model Registration Law

Approval was voted of the revisions in the Model Law for the Registration of Professional Engineers and Land Surveyors.

War Production Committee

Discontinuance of the present War Production Committee was voted, and the president was authorized to appoint a planning committee under the chairmanship of James L. Walsh to study the proper functions and personnel of a new committee to be known as the National Security Committee "to co-operate with the Army and Navy in the continued interests of national security."

Group Delegates Conference

The recommendations of the 1945 Group Delegates Conference, presented to the Council at its June meeting, were considered by the Executive Committee and referred to the committees concerned for comment. On the basis of these comments the Executive Committee took certain actions and made certain statements which are available in mimeographed form, "Summary of Actions by the Council on Recommendations of the 1945 Group Delegates Conference."

American Rocket Society

Authorization was voted of the affiliation of the American Rocket Society with the A.S.M.E., with the understanding that there will be no financial obligation because of the affiliation.

E.C.P.D. Resolution

Approval was voted of a resolution of the Engineer's Council for Professional Development on engineering personnel in the Armed Forces as affected by Selective Service.

Hoover Medal

It was reported that Major General William Henry Harrison, vice-president, American Telephone and Telegraph Company, had been elected the 1945 recipient of the Hoover Medal.

Appointments

The following appointments were approved:

Honorary chairmen of Student Branches, 32 reappointments and 17 appointments.

Gantt Medal Board of Award, John A. Willard (four years), and David B. Porter (three years to fill the unexpired term of L. A. Appley, resigned).

Lafayette College, inauguration of president, Oct. 26, 1945, Paul B. Eaton and F. V. Larkin.

Pennsylvania Has New Engineers' Registration Law

BECAUSE of changes in similar acts in other states, the decisions of the Dauphin County Courts of Pennsylvania, and the decision of the Illinois Supreme Court which declared the Illinois Act illegal, the need for a modern professional engineers' registration law had become more pronounced since 1927, the date of the previous Act.

In order to meet the objections of the Illinois Supreme Court, which held its act vague and indefinite, new definitions have been included which broaden the scope of the act and permit the licensing of the newer fields of engineering which are combinations of the main engineering branches such as civil, mechanical, electrical, and mining engineering.

The modern trend of all professions has been the granting of licenses after the successful passing of an examination. This is a fairer method as it practically eliminates the personal equation. Provisions are made for the applicant to take the examination in that branch of engineering for which he is best qualified.

The innovation in this act is the classification "Engineer-in-Training." This provision is made so that an applicant can take his examination in fundamental engineering principles when he is best fitted to do so. This is equivalent to the preliminary examination in law or medicine. Following the practice

of the legal and medical professions, if an applicant is a graduate of an approved engineering institution, he is granted a Certificate of Engineer-in-Training without an examination. Thereafter, all he needs to pass, after he has had the required four years of experience, is an examination in engineering practice. Applicants who are not graduates can take these examinations separately or at the same time.

The years of experience of a graduate have been increased to four to meet a similar requirement of all other states and makes possible reciprocity on an equal basis.

The Registration Board is given the power to license engineers without examination where such engineers are licensed in other states, provided such states likewise license engineers registered in Pennsylvania. The Board also has the power to grant a license without an examination to those applicants who have a Certificate of Qualification from the National Council of State Boards of Engineering Examiners, which is an organization composed of only engineering registration boards of all forty-six states having licensing laws.

Any dissatisfied applicant has a right to appeal to the Dauphin County Courts and from there to the Superior Court.

The act will become effective on June 30, 1946, thus giving an opportunity to all of those who desire to make application before that date, in order to avoid the necessity for taking an examination.

The act also provides for the practice of engineering by firms or corporations. In the past this has been a source of irritation. There are quite a number of such organizations, which are capable and necessary to handle large engineering projects and which have been in existence for many years.

Herty Elected President of Metals Society

DR. CHARLES H. HERTY, JR., of Bethlehem, Pa., was elected national president of the American Society for Metals.

Other officers elected were: A. L. Boegehold, head of the metallurgy department, Research Laboratories Division, General Motors Corporation, Detroit, Mich., vice-president; H. K. Work, manager of research and development, Jones & Laughlin Steel Corp., Pittsburgh, Pa., treasurer; John Chipman, professor of metallurgy, Massachusetts Institute of Technology, Cambridge, Mass., and W. E. Jominy, chief metallurgist, Dodge Chicago Plant, Chrysler Corporation, Chicago, Ill., trustees.

W. P. Kimball Elected Dean of Engineering at Dartmouth

ANNOUNCEMENT has been made of the election of Prof. William P. Kimball as dean of the Thayer School of Engineering at Dartmouth College, Hanover, N. H. Dean Kimball, who assumed his post on Nov. 1, 1945, has been acting dean of the school and was previously assistant dean under the late Frank Warren Garran.

Kinzel Heads Engineering Foundation

AT its annual meeting on Oct. 18, 1945, the Engineering Foundation elected Dr. A. B. Kinzel as chairman for the coming year. Dr. Kinzel is vice-president of the Union Carbide and Carbon Research Laboratories, Inc., and of the Electro Metallurgical Company. He has been senior consultant of the Metals Branch of the War Production Board, and is now chief consultant on metals to the Enemy Branch of the Foreign Economic Administration. His activities extend into the professional technical societies including the International Commission for Acetylene and Arc Welding and the Committee on Metals of the National Academy of Science. Other officers elected were vice-chairman Dr. L. W. Chubb, director of the research laboratories of Westinghouse Electric Corporation; Dr. Edwin H. Colpitts, formerly director of the Bell Telephone Laboratories, who was re-elected director, and John H. Arms, re-elected secretary. Dr. Kinzel will represent the Engineering Foundation on the Executive Board of the National Research Council.

During the year just ended, the Foundation has participated in eleven researches, all associated with some phase of war work, and covering the various fields of engineering. The subjects included soil mechanics and foundations, critical-pressure steam boilers, plastic flow of metals, and co-operation with the Welding Research Council, Engineers' Council for Professional Development, and the National Academy of Sciences.

The Engineering Foundation was established in 1913 for "the furtherance of research in science and engineering and for the advancement in any other manner of the profession of engineering and the good of mankind."

J. M. R. Fairbairn to Receive Sir John Kennedy Medal

THE Sir John Kennedy Medal for 1945, given by The Engineering Institute of Canada, is to be presented to Dr. J. M. R. Fairbairn, retired chief engineer of the Canadian Pacific Railway, at the next annual meeting of the Institute in February.

The medal, which is awarded as a recognition of outstanding merit in the profession, commemorates the great services rendered to the development of Canada, to engineering science, and to the profession, by the late Sir John Kennedy, past-president of the Institute.

Dr. Fairbairn, also a past-president of The Engineering Institute of Canada, is a member of The Institution of Civil Engineers, London, England, an honorary member of the American Society of Civil Engineers, and a member of the American Railway Engineering Association.

Parks Appointed Metals Society Editor

JOHN M. PARKS has joined the staff of the American Society for Metals as editor of technical books. He will also assist in the work of the Educational Committee and prepare lecture series for use by the 69 local chapter groups of the society.

Mack Printing Company Honored by A.S.M.E.

ON Oct. 26, 1945, members of the Executive Committee of The American Society of Mechanical Engineers and of the Committee on Publications of the Society and members of the A.S.M.E. Staff were hosts at a luncheon at the Engineers' Club, New York, N. Y., in honor of Harvey F. Mack, president, Mack Printing Company, Easton, Pa., in commemoration of twenty-five years of association between the Society and the Company. The Mack Printing Company has printed MECHANICAL ENGINEERING, the Transactions, and other Society publications, including the Mechanical Catalog, during this period, and the luncheon was given in recognition of the satisfactory relationships which have existed between the two organizations.

Alex D. Bailey, President of the Society, presided at the luncheon and presented an illuminated certificate to Mr. Mack, who expressed his thanks and recalled many incidents of the past twenty-five years. George A. Stetson, editor of the Society, expressed the appreciation of the A.S.M.E. staff for the faithful services of the Mack employees.

The certificate, which was signed by Mr. Bailey and C. E. Davies, secretary of the Society, read as follows:

"On behalf of The Council and Staff of The American Society of Mechanical Engineers, the President and Secretary extend to the employees of the Mack Printing Company, Easton, Pa., through its President, Harvey F. Mack, this expression of appreciation and good will which commemorates twenty-five years of satisfactory business relationships between the Society and the Company as printers of MECHANICAL ENGINEERING and other Society publications."

Landon Appointed Dean of Engineering at Akron

R. D. LANDON has been appointed dean of the College of Engineering of The University of Akron, services to commence on February 1, 1946.

R. D. LANDON

Professor Landon is a graduate of The University of Cincinnati and is now professor of Civil Engineering in the Southern Methodist University, Dallas, Texas. The present dean, Fred E. Ayer, will continue on the faculty until the time of his retirement in June, 1947.

S.P.E.E. to Meet in St. Louis, June 20–23

IT has been announced that the 53d Annual Meeting of the Society for the Promotion of Engineering Education will be held in St. Louis, Mo., June 20–23, 1946, with headquarters at the Jefferson Hotel. Washington University will be the host of the Society.

D. S. KIMBALL AT DINNER IN HONOR OF HIS EIGHTIETH BIRTHDAY
(*Left to right:* D. S. Kimball, J. Paul Leinroth, and D. Robert Yarnall.)

D. S. Kimball Honored by Cornell Alumni

ON Oct. 18 one hundred friends and former students assembled at the Cornell Club in New York City to celebrate the eightieth birthday of Dexter S. Kimball, honorary member and former president of the A.S.M.E. and dean-emeritus of the College of Engineering, Cornell University. The testimonial was held under the sponsorship of the Cornell Society of Engineers, with J. Paul Leinroth, president, in charge.

D. Robert Yarnall, president-elect of the A.S.M.E., extended the felicitations of the Society to Dean Kimball. S. C. Hollister, member A.S.M.E., dean of engineering at Cornell, told of Dr. Kimball's long leadership in education and engineering and of his work in the last war.

Dean Kimball spoke in his usual jovial style. The years have dealt lightly with him and at an age when other men would think of taking life easy, he is still planning things to do.

Among the many A.S.M.E. members present were Dr. Harvey N. Davis, past-president, Clarence E. Davies, secretary, Ernest Hartford, executive assistant secretary, and Erik Oberg.

Employment of Returning Veterans and Displaced Warworkers

RETURNING veterans and displaced warworkers who are scientifically and professionally qualified and who are seeking employment in industry, nonprofit research institutions, colleges, and universities are offered the help and the extensive resources of the National Roster of Scientific and Specialized Personnel. Many veterans plan to return to their former employers and need no help. Many industries can shift their technical staffs from war to peace production. On the other hand, a number of plants are not able to absorb the staffs formerly engaged in war production in their peacetime operations. All this adds up to a large amount of change and readjustment. Numerous statements have been made, apparently on good authority, that there are personnel shortages in most of the professions. It remains for an agency such as the National Roster operating on a nation-wide basis to assist all other efforts on the part of professional societies and individuals to find employment for all those who are rapidly becoming available.

Separation centers of the Armed Forces are co-operating with the National Roster to assist professionally qualified veterans to find employment in civil life. Return postcards and application and registration blanks are provided, and each center will be supplied at least every two weeks with a current list of positions that are open. The placement section of the National Roster will send brief statements regarding applicants to employers who have placed job orders with the Roster. In order to save time and increase chances of placement, these summaries are sent at the same time to several different employers having identical requirements.

Technical and professional personnel leaving war industries are invited to notify the National Roster that they are available for employment. If any are not already registered with the Roster, registration blanks will be sent to them promptly on request.

All employers who are not able to retain their full staffs and who wish to assist those of their professional employees who are leaving are asked to advise these individuals to ask aid of the Roster. Employers who are in need of additional personnel should send to the Roster descriptions of the positions which they wish to fill, together with detailed requirements as to age, extent of education, and specify the amount and nature of their experience.

Professional and technical societies that are engaged in organized efforts to place members of their professions are privileged to ask the co-operation of the National Roster.

The Roster is prepared to undertake placement in practically all professional fields except in elementary and high-school teaching, and does not restrict its help to the fields in which it maintains its registry.

The address is: National Roster of Scientific and Specialized Personnel, 1006 U Street, N. W., Washington 25, D. C.

A.W.S. Elects Officers and Awards Prizes

DR. WENDELL F. HESS, professor of metallurgical engineering and head of the welding laboratory, Rensselaer Polytechnic Institute, Troy, N. Y., has been elected president of the American Welding Society for the year 1945–1946. He took office at the Annual Meeting of the Society held on Oct. 18, 1945, in New York, N. Y.

Other officers elected were: First vice-president, Harold O. Hill, member A.S.M.E., assistant chief engineer, fabricated steel construction, Bethlehem Steel Company, Bethlehem, Pa.; second vice-president, George N. Sieger, president and general manager of the S-M-S Corporation of Detroit, Mich.

Directors-at-large elected for a period of three years are: C. M. Underwood, manager, welding department, Northern Ordnance, Incorporated, Minneapolis, Minn.; Dr. A. B. Kinzel, vice-president of the Electro-Metallurgical Company and of Union Carbide and Carbon Research Laboratories, Inc.; Charles H. Jennings, section engineer, welding section, Westinghouse research laboratories, East Pittsburgh, Pa., and R. D. Thomas, president, Arcos Corporation, Philadelphia, Pa.

Honorary Memberships

Honorary memberships in the Society were conferred upon D. S. Jacobus, honorary member and past-president, A.S.M.E.; H. C. Boardman, member A.S.M.E., research engineer for the Chicago Bridge and Iron Company, Chicago, Ill., and J. H. Deppeler, member A.S.M.E., chief engineer of the Metal and Thermit Corporation, New York, N. Y. In addition, Mr. Deppeler was the recipient of the Samuel Wylie Miller Memorial Medal for 1944.

The Miller Medal is awarded annually to the person who conspicuously contributed to the advancement of the welding and cutting of metals.

Lincoln Medal presented to L. C. Bibber

Leon C. Bibber, welding engineer for the Carnegie-Illinois Steel Corporation, received this year's award of the Lincoln Gold Medal and Certificate. This valued prize is given annually to the author or authors of the paper published in the *Welding Journal* which represents the greatest original contribution to the advancement and use of welding. Mr. Bibber's prize-winning paper entitled "Tensile Properties of Heavy Longitudinally-Welded Plate Specimens Simulating Deck and Shell

Joints," appeared in the April, 1945, issue of the *Welding Journal*.

Dr. S. L. Hoyt Delivers Adams Lecture

Dr. Samuel L. Hoyt, technical adviser, Battelle Memorial Institute, Columbus, Ohio, delivered the Adams Lecture at this meeting. The Comfort Avery Adams Lecture is given annually by a man who is outstanding for attainments in the science and art of welding, and is named in honor of the first president of the Society.

Prizes Awarded for Resistance Welding Papers

The following men were awarded prizes by the Resistance Welding Manufacturers Association: L. A. McIntosh of the McIntosh Stamping Corporation, Detroit, Mich., received $500 for a paper entitled "Resistance Welding for Economy and Quality;" Dr. W. F. Hess, newly elected president of the Society; R. A. Wyant, assistant professor of metallurgical engineering at Rensselaer Polytechnic Institute; and B. L. Averbach, metallurgist in the works laboratory of the General Electric Company, Schenectady, N. Y., received $200 jointly for the best paper from a university source, entitled "The Surface Treatment at Room Temperature of Aluminum Alloys for Spot Welding;" G. W. Scott, L. G. Sutton, and J. H. Widmeyer, all of the research laboratory of the Armstrong Cork Company, Lancaster, Pa., $200 for best paper from an industrial source entitled, "Radiography for Development and Control of Aluminum-Alloy Spot Welding;" and J. C. Barrett, research metallurgist, The Glenn L. Martin Company, Baltimore, Md., $100 prize for the paper entitled, "Flash-Welding of Alloy Steels—Physical and Metallurgical Characteristics."

E.C.P.D. Elects Officers at 1945 Annual Meeting

AT the 1945 Annual Meeting of the Engineers' Council for Professional Development, which was held in the Engineering Societies Building, New York, N. Y., on Oct. 19 and 20, Everett S. Lee, engineer of the General Engineering and Consulting Laboratory, General Electric Company, Schenectady, N. Y., was re-elected chairman, and James W. Parker, president, general manager, and director, The Detroit Edison Company, Detroit, Mich., was re-elected vice-chairman. Wm. N. Carey, secretary and executive officer of the A.S.C.E., and H. H. Henline, national secretary, A.I.E.E., were elected secretary and assistant secretary, respectively.

Chairmen of Committees

For chairmen of E.C.P.D. committees the following elections were announced: Committee on Student Selection and Guidance, Carl J. Eckhardt, Jr., professor of mechanical engineering and superintendent of utilities, University of Texas; Committee on Engineering Schools, D. B. Prentice, president, Rose Polytechnic Institute; Committee on Professional Training, C. A. Pohl, consulting engineer, New York, N. Y.; Committee on Professional Recognition, N. W. Dougherty, dean of engineering, University of Tennessee.

Representatives to E.C.P.D. appointed by the constituent bodies were announced as follows: Scott Lilly, A.S.C.E.; A. F. Greaves-Walker (reappointment), A.I.M.E.; John E. Younger, A.S.M.E.; M. S. Coover, A.I.E.E.; D. B. Prentice (reappointment), S.P.E.E.; de-Gaspé Beaubien, E.I.C., and George M. Shephard, N.C.S.B.E.E.

Serving on the Executive Committee, E.C.P.D., for the coming year, will be: R. E. Bakenhus, A.S.C.E.; W. B. Plank, A.I.M.E. R. L. Goetzenberger, A.S.M.E.; M. S. Coover, A.I.E.E.; S. D. Kirkpatrick, A.I.Ch.E.; H. S. Rogers, S.P.E.E.; C. R. Young, E.I.C.; and C. C. Knipmeyer, N.C.S.B.E.E., as well as the chairman, vice-chairman, secretary, and assistant secretary.

Annual Banquet

At the annual banquet on Friday evening, E. S. Lee, presiding, the general subject of discussion was "E.C.P.D. and the Engineering Profession." Mr. Lee read his annual report. A. R. Cullimore, retiring chairman, Committee on Student Selection and Guidance, spoke with feeling on "The Veteran Returns," and R. L. Sackett, retiring secretary, delivered an address "The Future of E.C.P.D."

A.S.C.E. Inaugurates Public Information Service

INAUGURATION of a public-relations program by the American Society of Civil Engineers has been announced by Colonel William N. Carey, secretary and executive officer.

In making the announcement, Colonel Carey stated the society will endeavor to make the general public more familiar with civil engineers and their work nationally and in their respective communities.

To inaugurate and conduct the program, Allen Wagner, public-relations director of Minnesota Mining and Manufacturing Company, with headquarters at St. Paul, Minn., and a former newspaper man who served on Twin Cities papers, has been named public-relations assistant to Colonel Carey. He will carry on his work from the society's headquarters.

Material Handling Society Formed In Pittsburgh

AT a dinner meeting held in the Roosevelt Hotel in Pittsburgh, Pa., on Oct. 8, 1945, a group of men interested in material handling voted to form a society.

A group of objectives was suggested for the Society which included: (1) To further the application of good material-handling practices; (2) to encourage an interchange of ideas among the members; (3) to promote education and training in the science and practice of practical co-ordinated material handling, and (4) to arrange for the collection and dissemination of information relating to all phases of material handling.

Temporary officers elected were: Temporary chairman, T. O. English, Aluminum Co. of America; temporary secretary, Richard Rimbach, Materials Publishing Company. The following committees were elected: Program Committee, Fred W. Bradley, National Adhesives Division of National Starch Products, Inc., chairman; Martin A. Lyons, Westinghouse Electric Corp., and E. L. Niederhofer, Chemical Plants Division, Blaw-Knox Co., members. Constitution Committee, D. B. Hendryx, Harbison-Walker Refractories Co., chairman: Louis E. Dietrich, P. Duff and Sons, and Jay Overpeck, J. H. Overpeck Co., members. Nominating Committee, F. Gordon Ricker, Yale & Towne Manufacturing Co., chairman, Samson A. Huey, P. Duff and Sons, and James M. Phillips, Phillips Mine and Mill Supply Co., members. Membership Committee, Fred Benjamin, Kress Box Co., chairman, O. Heidenreich, Elwell-Parker Electric Co., and J. L. Logan, Hagan Corp., members.

Further information may be obtained from the temporary secretary, Richard Rimbach, 1117 Wolfendale Street, Pittsburgh 12, Pa.

A.S.T.M. to Meet in Buffalo and Pittsburgh

THE Executive Committee of the American Society for Testing Materials has confirmed an earlier decision to hold the forty-ninth annual meeting of the society in Buffalo, N. Y., from June 24 to 28, 1946, and in conjunction therewith to have the seventh exhibit of testing apparatus and related equipment.

The 1946 spring meeting of the society will be held in Pittsburgh, Pa., during the week of February 25 to March 1. This week will also be A.S.T.M. Committee Week during which there will be many meetings of A.S.T.M. technical committees.

Further announcements will be made concerning the technical features of both the annual and spring meetings. Several extensive symposiums are being developed and there will be a large number of technical papers and committee reports.

A.S.A. Broadens Its Scope

CHANGES in the constitution of the American Standards Association that will enable it to meet more fully the needs of government and industry in the postwar period have been announced today by P. G. Agnew, secretary A.S.A. The national trade, technical, and governmental groups that make up the American Standards Association have ratified these changes, the principal one of which will remove present restrictions limiting the work of A.S.A. "to those fields in which engineering methods apply" so that the organization can in the future handle any standard or standardization project which is in the field of engineering or consumer goods or in any other field which deserves national recognition.

Another change provides for specific mention of the consensus principle in the constitution. This principle—that all groups with an interest in a particular standard have a right to a voice in its development—has always been basic in A.S.A. operations.

A third change provides for election to the board of directors of three members at large. At present all but the ex-officio members of the board are nominated in rotation by the member bodies. The additional members at large will make it possible to enlist the services of outstanding persons from groups not otherwise represented, thus making the board still more broadly representative.

President's Page

ANOTHER A.S.M.E. year has passed; as a result of the Annual Meeting just held a new administration has been installed. As we take office, we want to thank the outgoing administration for the splendid way in which it has managed the affairs of the Society, as evidenced by the record we find.

Ours is a great profession and our Society, now with over 20,000 members, 70 Sections, and 120 Student Branches, is a most important group in this great profession. Largely because of our size, we have now changed our Society's structure by the election of eight Regional Vice-Presidents, whose duty it shall be to keep in very close touch with the Sections and Student Branches and professional activities in their districts. It will be our firm policy in the coming year to support and help these vice-presidents.

Now that the war is over, ours will be the first full year of reconstruction—of reconversion. Engineers are always expected by their countrymen efficiently to design and build the sinews of war; the general acclaim indicates that these jobs have been well done. We know that the country can count on engineers with equal confidence not only to "beat swords into ploughshares and spears into pruning hooks," but to help insure, through their sense of citizenship responsibility, "that this Nation, under God, shall have a new birth of freedom."

Let us move forward as a well-integrated part of our profession and as good citizens in response to this high calling.

Your new administration pledges itself to maintain the high standards which have always been the background of our work and which have been so ably maintained by our predecessors.

D. ROBERT YARNALL, *President* A.S.M.E.

Local Sections

Joint Meeting of The Engineering Institute of Canada and Detroit Section

ON Oct. 5 the Section joined with The Engineering Institute of Canada in a meeting held in the Rackham Building, Detroit, Mich. Members of the Institute's Border Cities Branch and other Ontario branches, as well as representatives from Montreal, were present. A visit was made to the plant of the American Blower Company to see the research and development laboratories.

The dust laboratories were shown, where samples of air, taken from various sources, were heated in such a way that their dust content was separated and analyzed for the purpose of determining methods by which it could be separated in the original location as an aid to health, comfort, and the processes of the industry itself.

A visit was made to the sound laboratory. Here, by means of elaborate insulation, a very low level of normal sounds was obtained and in this quiet atmosphere tests were run on rotating equipment manufactured by the company. By means of waves picked up on a microphone, the volume of sound was recorded in decibels on a meter. The shape and motion of the sound waves was also projected onto a dark screen so that a minute study could be made of them. This was an example of looking at sound. The high light of the demonstration was the use of a stroboscopic device by which the rotating fan could be seen as if standing still. Every detail of the fan construction was as clearly visible as if the fan were motionless. Heavy fans were shown in motion, such as those used for industrial operations or for ventilation. The difference between axial flow and rotary flow of air was shown, and the purposes of each explained.

After the plant inspection, the group met for dinner. J. E. Armstrong, vice-president of the Institute, presided and introduced the speaker, Gen. Andrew G. L. McNaughton, honorary member A.S.M.E., who spoke on "Canadian Engineering in the War." The text of his address is found on pages 839–842 of this issue. Three hundred fifty members and guests were present.

Akron-Canton Section Features Talk on Atomic Bomb

Dr. W. L. Davidson, Jr., research physicist with the B. F. Goodrich Company, was the guest speaker at the meeting on Sept. 27 in the Y.W.C.A. at Akron, Ohio. He discussed the foremost subject of the day, "The Atomic Bomb," to an interested audience of 101 members and guests. Dr. Davidson is co-author, with Prof. Ernest Pollard, of the book "Applied Nuclear Physics."

At the Oct. 25 meeting of the Section at the Women's City Club, Akron, Ohio, W. T. Piper, president and chairman of the board, Piper Aircraft Corporation, Lock Haven, Pa., spoke on "Light Planes and Airports." Because of widespread interest in this subject, the meeting was open to the public. Mr. Piper discussed the development of the plane from its conception, both good and bad points of a plane, prewar production, and postwar possibilities.

"Locomotives of the Future" Anthracite-Lehigh Valley Section Topic

J. R. Grove, general manager, Lehigh Valley Railroad Company, was the speaker at the Oct. 26 meeting at the Hotel Traylor, Allentown, Pa. In his talk entitled "Locomotives of the Future," Mr. Grove gave an outline of the various types of locomotives now in use, and explained the characteristics of each which affect selection, such as first cost, maintenance, availability, and operating characteristics, from the point of view of an operator rather than a designer or builder. The talk was intensely practical, based on dollars-and-cents economy and the lively open discussion which followed attested to the interest aroused.

Atlanta Section Meets With Georgia Engineering Society

The Oct. 15 meeting was held at Davidson's tea room, Atlanta, Ga., as a joint meeting with the Georgia Engineering Society. Prof. William N. Cox spoke on "Industrial Safety," and in his talk stressed the number of avoidable accidents in industry, giving many examples of how accidents were minimized, such as by rest rooms on each floor to cut down elevator and stairway casualties. He enumerated studies in a new industrial safety course at Georgia Tech under the auspices of the National Safety Council. Ninety-two members and guests attended.

G. E. Tobey and E. C. Payne Speak at Boston Section

"Fuel Economics Affecting Power-Plant Design" was the subject discussed at the Oct. 18 meeting at Northeastern University, Boston, Mass., by J. E. Tobey, member A.S.M.E., managing director, coal bureau, Upper Monongahela Valley Association, New York, N. Y., and E. C. Payne, member A.S.M.E., consulting engineer, Consolidation Coal Company, New York, N. Y. The speakers emphasized the necessity in future power-plant design, of devoting more attention to the available fuel in a given district, their economic values, and the design of equipment to handle a wider range of fuels than has been the custom in the past. A total of 125 members and guests were present.

Bridgeport Section Hears Prof. W. Trinks

"Modern Research in Forging and Rolling" was the subject at the Oct. 4 meeting at the Barnum Hotel, Bridgeport, Conn., with Prof. W. Trinks, member A.S.M.E., guest speaker. Ninety members and guests heard the lecture. Professor Trinks cited many examples of rejected or faulty work which had been submitted to him or to his A.S.M.E. Committee for study. He explained the analyses which were made and the corrections which were applied, together with the savings which resulted. He also told of recent improvements in the normal operating technique, explaining the deformation and forming of marble by hydraulic pressure.

James Partington Speaker at Buffalo Section

On Oct. 16 a dinner meeting was held at the Markeen Hotel, Buffalo, N. Y. The speaker was James Partington, member A.S.M.E., manager, engineering department, American Locomotive Company, New York, N. Y., who gave a talk on "Locomotives—Steam, Electric, and Diesel." He gave a brief summary of various types of locomotives, when first introduced, illustrating various types with slides, and describing the advantages of different types. He also discussed a new welded-type locomotive boiler which has been tested for the past seven years. A discussion period followed the lecture.

Chicago Section Hears Dean O. W. Eshbach

The annual fall "get-together" was held on Sept. 28 at the Continental Hotel, Chicago, Ill. The meeting was well attended, and all enjoyed the dinner and excellent entertainment provided.

On October 3 at the Northwestern Institute of Technology, Evanston, Ill., the speaker was Dean O. W. Eshbach of that Institute. In the course of his talk on "Postwar Engineering School Plans," Dean Eshbach pointed out that the number of students desiring an engineering education in the postwar era will be about 200,000 annually, whereas the schools can accommodate only 100,000. This, he said, presents a great problem in the country. After the lecture an inspection trip was made of the engineering-school facilities.

One hundred members and guests enjoyed an address by Dr. John J. Grebe, member A.S.M.E., director, physical-research laboratory, Dow Chemical Company, Midland, Mich., on Oct. 22, at the Electric Club, Chicago, Ill. Dr. Grebe's subject was "Unusual Control Problems." He discussed basic control problems, successful solutions of unusual control problems, and introduced in his talk some fine engineering philosophy. The lecture was illustrated with many photographs taken in the Dow Chemical Company's plants, with diagrams of some of the applications of control to production of Dow products from deep-well and sea water. There were also moving pictures of the production and fabrication of magnesium. Army Air Force animated, educational, sound films were also shown, illustrating some of the electronic applications to gun control.

Social Meeting Feature at Cleveland Section

The first meeting of the season, held on Oct. 11 at the University Club, Cleveland, Ohio, was a social one, combining a cocktail hour, dinner, and entertainment for the members and their wives. Forty-seven members and guests enjoyed the evening's entertainment.

Talk on "The Atomic Bomb" Featured at Colorado Section

The first meeting of the season was held on Oct. 12 at the Oxford Hotel, Denver, Col. After dinner, Dr. W. B. Pietenpol, head of the physics department, and professor of physics, University of Colorado, gave a talk on "The Atomic Bomb." After developing historically the present knowledge of atomic structures, Dr. Pietenpol described the isotopes of uranium and the methods of production. He also discussed the control of chain reactions which lead to violent energy release. Following his very interesting talk, a spirited question period contributed to the evening's interest.

"New Electric Micrometer" Subject at Columbus Section

The new season was opened with a meeting on Oct. 30 at the Battelle Memorial Institute. The speaker was G. M. Foley, research engineer with the Institute, who described the development and operation of the electric micrometer in connection with the testing of precision lathe spindles. The instrument was developed with a sensitivity which made it capable of measuring a distance as small as 0.00000001 of an inch.

"Number Recording" Discussed at Dayton Section

On Oct. 16 a meeting was held at the National Cash Register Company's building, Dayton, Ohio, when Gunnar Nelson, head resident engineer, National Cash Register Systems, spoke on the "History and Development of Number Recording." Mr. Nelson described the number systems and records, the basic tools of science and business, from aboriginal to present forms. He said that the use of zero to add positional values to digits enabled science and business to achieve present-day growth. Fifty members and guests were present.

Pan American Airway Official at Kansas City Section

"Aviation and Foreign Affairs" was the subject at the Oct. 15 meeting held in the University Club, Kansas City, Mo. The speaker was J. Carroll Cone, assistant vice-president, Pan American Airways. Mr. Cone was himself an airplane pilot for many years, is a colonel in the Army Air Force Reserve, holds a military airplane-pilot's rating, and for four years previous to his promotion to his present duties organized and was manager of the Atlantic division of the Pan American Airways. In his talk, Mr. Cone said that European countries are persuading us to promote "Freedom of the Air," so that they, through their American possessions who would sign the pact, can fly around the world across our Pacific possessions, and still keep us out of their countries. In view of this, Mr. Cone felt that we should form a government - controlled combine to fly the ocean and compete with foreign lines.

J. C. CONE

Louisiana Section Hears I. J. Karassik

On Sept. 19 a meeting was held in Arnaud's restaurant, New Orleans, La., when Igor J. Karassik, member A.S.M.E., Worthington Pump and Machinery Corporation, Harrison, N. J., spoke on "High Pressure Boiler Feed Pumps." He explained that design, materials, application, and operation are the four factors of equal importance in the successful use of centrifugal boiler feed pumps. Pump design, he said, has not kept pace with boiler design for high pressures but is now catching up, and investigations are now under way which will provide complete information regarding proper materials for feedwaters with various total solids. Mr. Karassik said that engineers are giving more thought to make certain the pump fits the job and that proper operation can assure trouble-free boiler feeding. Fifty-nine members and guests attended.

R. V. Wright at Engineers' Forum of Metropolitan Section

The responsibilities of the engineer in the field of citizenship and the need in public affairs of the engineer's analytical abilities were forcefully enunciated by Roy V. Wright, vice-president, Simmons-Boardman Publishing Company, New York, N. Y., past-president and honorary member A.S.M.E., in a talk on the subject, "The Engineer's Status in the Community," at a meeting of the Engineers' Forum of the Metropolitan Section, held in the Engineering Societies Building, October 23, 1945.

Dr. Wright, who has an outstanding record of public service in his local community of East Orange, N. J., and in the State Legislature of New Jersey, spoke against a background of practical political experience when he pronounced with force and enthusiasm, "The engineer has a very definite responsibility in the field of citizenship which he can no longer afford to neglect."

The awakening interest of the engineering profession to matters of civic import was confirmed by Dr. Wright when he outlined the program already formulated by one group of the A.S.M.E. for the development of a spirit for public service among the sections.

In speaking of an award that could be given to young engineers under 35 years of age for meritorious public service, Dr. Wright declared, "If such an award were available I'd have no trouble in finding a worthy recipient."

A. Ehbrecht, Gries Reproducer Corporation, opened the meeting with a welcome to all present. He reviewed the purpose and some of the high lights in the 14 years during which the Engineers' Forum has been active. He explained that the "forum" was organized to give members of the Metropolitan Section an opportunity to express their opinions and to develop their ability for extemporaneous speaking.

Talk on Stainless Alloys, and Plant Inspection at the Mid-Continent Section

C. Holmberg, metallurgist, was the speaker at the Oct. 18 meeting at the Tulsa Boiler and Machinery Company's plant at Tulsa, Okla. In his talk entitled, "Stainless Alloys and Their Application to Pressure Vessels," Mr. Holmberg discussed the different types of stainless steel alloys, and explained their uses and weldability in pressure-vessel ap-

PUBLICITY COMMITTEE OF MILWAUKEE SECTION IN ACTION

(Some of the members of the Publicity Committee get together to lay plans for the coming year. Shown, *left to right*, are Walter Alexandroff, Pate Oil Company; James G. Weber, Ampco Metal Inc.; and James Karr, Kearney & Trecker Corporation. Members of this committee, not shown, are Robert Cunningham, Allis-Chalmers Manufacturing Co.; Alfred Meeg, Iron Fireman Company; and Thomas Pleyte of the Le Roi Company. This committee is striving to promote a lively interest in A.S.M.E. activities in conjunction with the program committee.)

MR. HOPPE, *right center*, GATHERS WITH SOME OF THE A.S.M.E. MEMBERS IN FRONT OF ONE OF THE 5400-HP DIESEL ENGINES USED BY THE MILWAUKEE ROAD

plications. The use of heat-treatment on the structure of welded stainless steel was also discussed. Following his talk, a tour of the plant was made, to inspect the various stages of manufacturing welded pressure vessels. Sixty-four members and guests were present at the meeting.

Inspection Tour and Lecture at Milwaukee Section

On Oct. 10 the members visited the Milwaukee Road shops, where the host was the Chicago, Milwaukee, St. Paul and Pacific Railroad Company, with A. G. Hoppe, assistant chief mechanical engineer of that company, as guide. The carshops and roundhouse of the railroad were shown, and inspection revealed the various stages of wheel and axle assembly and maintenance, the forge plant where all metal equipment is prepared for assembly, the multiple wheel-grinding operations, and the large assembly plant where boxcars are produced on a mass-production basis.

A dinner followed at the City Club, Milwaukee, Wis., where Mr. Hoppe continued his talk, giving an interesting history of the development of passenger coaches and trucks. The talk was supplemented with slides.

On Oct. 13 the section was the guest of the U. S. Navy on a tour through the submarine U.S.S. *Mero*, last of 28 submarines built at Manitowoc, Wis. Members were allowed to bring their families, and it became a gala event. From an engineering standpoint, the gleaming controls, carefully located equipment, instrument and control rooms, living quarters, and the exacting details provided to facilitate the crucial purpose of the submarine, were a startling revelation to those not acquainted with naval design.

Atomic Energy Discussed at North Texas Section

A most interesting talk was heard at the Oct. 15 meeting held at the Y.M.C.A., Dallas, Tex., when George E. Kidd, member A.S.M.E., Magnolia research laboratory, Magnolia Petroleum Company, Dallas, Texas, spoke on "Historical Developments of Atomic Energy." Mr. Kidd traced the developments in atomic physics from the time that Dr. Enrico Fermi discovered the possibilities of the slow neutron, and discussed all later developments which led to the actual construction and use of the atomic bomb. He explained the difference between the process used for the physical separation of uranium 235 from raw uranium as opposed to the chemical production of plutonium. The audience agreed that this was one of the finest talks ever presented before the Section.

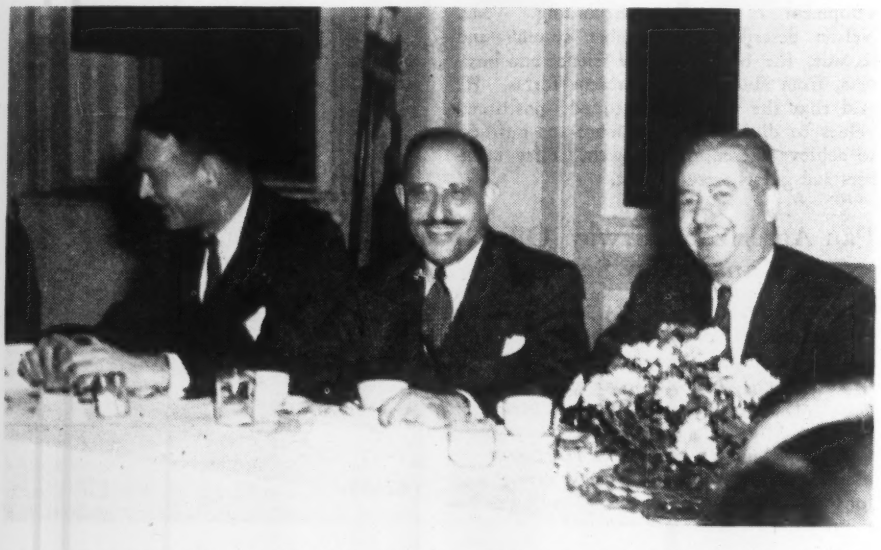
Ontario Section Opens Season With Plant Trip and Dinner Meeting

At the first meeting of the 1945–1946 season, on October 11, a visit was made to the modern Clarkson Refinery of the British American Oil Company, Toronto, Ont., Can. Before the tour F. B. Conron described the refining process of the plant as a whole, and W. J. McNeely explained the purification of lubricating oils. After the trip an excellent dinner was enjoyed by members and guests, at the Queen Elizabeth Lodge, in Toronto. The speaker, F. A. Davis, process engineer of the company, gave an interesting talk outlining the engineering features of the project. Guests at the dinner meeting, from the British-American Oil Co., included P. L. Paul, H. R. Hawthorne, F. B. Conron, W. J. McNeely, and A. H. Morris. Prof. R. C. Wiren, the local chairman, presided.

Talk on Petroleum Machines at Philadelphia Section

The Philadelphia Section held its first meeting under incoming chairman Justin J. McCarthy, on Oct. 23, at the Engineers' Club of Philadelphia, Philadelphia, Pa.

Following dinner, Dr. Lester M. Goldsmith, member A.S.M.E., and Melville Medalist 1939, chief engineer of The Atlantic Refining Company, spoke on "Petroleum Industry Machinery." He traced developments over the last thirty years, comparing old practice involving "batteries of stills" with present-day "combination units." Particular attention was devoted to developments in the pumping art, leading to 19-stage hot-oil pumps having discharge head of 10,000 ft and pipe-line pumps as used on the "Big Inch" capable of handling 325,000 barrels per day with an efficiency of 88 per cent. The speaker pointed out how pioneer work on higher pressures



DR. GOLDSMITH ENJOYS DINNER WITH MESSRS. MCCARTHY AND MACKENZIE BEFORE ADDRESSING THE PHILADELPHIA SECTION

and temperatures in the oil industry has served as a challenge and stimulus to steam-power engineers.

After the technical meeting, the crowd of approximately 250 remained for a social half hour and light refreshments.

Trenton Committee of Philadelphia Section

The Trenton Committee of the Section held a joint meeting with the Engineers' Club of Trenton, N. J., on Oct. 11 at the Hotel Stacy-Trent, Trenton, N. J. The speaker was Dr. Lionel S. Marks, professor of mechanical engineering, Harvard University, who presented a very interesting illustrated lecture entitled, "Recent Developments of Jet Propulsion and Rockets." Harns Gartman, vice-chairman of the Trenton Committee, introduced the speaker. Several hundred, including 40 A.S.M.E. members, attended. Several meetings are planned for the season by the Trenton Committee.

Rochester Section Meets With Rochester Engineering Society

A joint meeting with the Rochester Engineering Society was held in the Hotel Sheraton, Rochester, N. Y., on Oct. 11. The speaker was Dr. J. T. Rettaliata, junior member A.S.M.E., winner of the A.S.M.E. Junior Award, 1941, for his paper on "The Combustion Gas Turbine," and of the Pi Tau Sigma Award, 1942, for "Outstanding Achievement in Mechanical Engineering." Dr. Rettaliata is director, department of mechanical engineering, Illinois Institute of Technology, Chicago, Ill. He discussed some of the phenomena and principles in the development and application of the gas turbine, the difficulties encountered, and the extensive research required to obtain direct transfer from burning fuel to kinetic energy. Dr. Rettaliata illustrated his talk with slides and sound films and aroused unusual interest of the audience, evidenced by the questions asked at the end of the meeting.

Radial Aircraft Engines Subject at Rock River Valley Section

On Oct. 26 at the Hotel Hilton, Beloit, Wis., D. R. Hoover, Buick Motor Division, General Motors Corporation, spoke on "Problems Experienced in Fabrication, Assembly, and Test of Radial Aircraft Engine." In his talk Mr. Hoover mentioned the difficulties in machining magnesium castings, cooling-fin design, use of torque wrenches, cold-working processes, tolerances compared to automobile engines, surface finish, dry sump operation, and various factors about inspection of parts and finished engines. Fifty-five members and guests were present.

Talk on U. S. Patent System at St. Joseph Valley Section

John W. Anderson was the speaker at the Oct. 9 meeting at the Spaulding Hotel, Michigan City, Ind. In his talk, "Incentive Propulsion of U. S. Patent System," Mr. Anderson brought out the interesting fact that Thomas Jefferson founded our patent system. The speaker then traced the progress made with the present incentive method, and the relentless effort made to reform our patent system. He also discussed the workings of the National Patent Council. Forty members and guests attended.

New Steam-Turbine-Driven Locomotive Described at San Francisco Section

A joint meeting was held by the Section with the Pacific Railway Club on Sept. 27, at the Engineers' Club of San Francisco, Calif. A powerful new steam-turbine-driven locomotive that bids fair to succeed the familiar "iron horse" for high-speed passenger and freight runs on the nation's railroads, was described and pictured by C. D. Allen, member A.S.M.E., Pacific Coast sales and service manager of the Baldwin Locomotive Works, and Donald R. Jenkins, junior member A.S.M.E., Pacific Coast steam engineer for the Westinghouse Electric Corporation.

Mr. Allen pointed to a joint study undertaken by Baldwin, Westinghouse, and the Pennsylvania Railroad, intended to produce a type of locomotive that would be designed free of prejudiced opinion and ulterior interest, but economically sound for all sections of the country as to first cost, operation, and maintenance, and which also would be adaptable to use any type of fuel. He said that the steam-turbine geared-drive locomotive is the first result of this study, and although it is not the last word in these efforts, it does indicate a trend of steam-power application which may give us a locomotive superior to any heretofore offered. Already tested in the Pennsylvania mountains and now undergoing further tests in service on regular runs between Chicago, Ill. and Crestline, Ohio, the new locomotive looks much like the conventional reciprocating steam-driven type but it is minus the "puffing" of a reciprocating locomotive, is more powerful and economical at high speeds, and pulls heavier trains faster. Mr. Jenkins said that the 6500-hp giant is powered by a main, or forward-drive, steam turbine no bigger than an electric refrigerator, and will pull passenger trains at 100 miles an hour and full-length freight trains at high speed. A smaller reversing turbine drives it at speeds up to 22 miles an hour in reverse.

Designated as type S-2, the new locomotive with its loaded tender weighs nearly 1,000,000 lb and covers 123 ft of track. It has a 6-8-6 wheel arrangement—6 leading wheels, 8 driving wheels, and 6 trailing wheels. The tender has a water capacity of 18,000 gallons and carries $37\frac{1}{2}$ tons of coal.

Dr. A. R. Stevenson, Jr., at Schenectady Section

One hundred members and guests attended the Oct. 18 meeting at the Hotel Van Curler, Schenectady, N. Y., when Dr. A. R. Stevenson, Jr., Fellow A.S.M.E., staff assistant to vice-president of engineering, General Electric Company, Schenectady, N. Y., discussed, under the title "You're Never too Old to Learn," engineering education, both undergraduate and postgraduate. He described the engineering training programs of his company, and their changes in emphasis from theoretical analysis to creative engineering. He stressed the continuing nature of education, particularly in cultural subjects which can often be better studied after graduation.

Inspection Trip Feature of South Texas Section

On October 20 the members visited the Brown Shipbuilding Company, Inc., plant at Green's Bayou, Houston Ship Channel. This inspection trip was conducted by Comdr. Michael I. Kearns, U.S.N.R., who was stationed throughout the war at the Brown Shipbuilding Company's Yards.

Susquehanna Section Hears Talk on Market Research—Related to Engineering

"Market Research and its Relation to Engineering" was the subject at the meeting on Oct. 8 at the Hotel Penn, York, Pa. The speaker, Edward R. Walsh, Jr., gave details of the exact procedure required for making a market survey to ascertain quantitatively what products should be manufactured. He said that a prediction of consumer demand by virtue of nation-wide studies utilizing professional help, governmental statistics, and national organizations to accumulate data, together with various applied factors, would finally result in a plausible production goal. He predicted a rapidly expanded future for the refrigeration and air-conditioning industries, with a growing need for trained engineering personnel necessary to meet consumer demands.

Charles A. Carlson Honored by Tri-Cities Section

On Sept. 25 at Moline, Ill., Charles A. Carlson, member A.S.M.E., was presented with the "Certificate for Meritorious Service to the Society," representing 25 years' service as secretary-treasurer of the Section. In his letter to the Society expressing his appreciation for this recognition and award Mr. Carlson said, "I am happy if I am credited with a small portion of the work required to maintain the Tri-Cities Section in action since its organization in 1920. Other faithful workers have co-operated with me at all times, and many efficient chairmen have been at the head, and at critical times carried a large part of the work to a successful finish. It is the assistance that I have had from these leaders that has helped me. Therefore, I cannot help but say sincere thanks to them first of all. Then I sincerely appreciate the forebearance and indulgence on the part of the headquarters' office in overlooking my shortcomings in the performance of my duties to the Society. I cannot tell how deeply appreciative I am for this recognition and your award."

Speaker at Utah Section Discusses Engineering in Postwar World

Capt. A. A. Nichoson, assistant to the vice-president, Texas Oil Company, was the speaker at the meeting on Oct. 8, held jointly with the American Institute of Electrical Engineers, at the Temple Square Hotel, Salt

Lake City, Utah. Capt. Nichoson, a veteran of World War I, addressed the audience on the subject of "Engineering—the Blueprint of the Postwar World."

Western Washington Section Visits Western Gear Works Following Talk

At the Oct. 3 meeting in the Engineers' Club, Seattle, Wash., S. L. Crawshaw, member A.S.M.E., manager of plants, California division, Western Gear Works, Lynwood, Calif., spoke on "Gears and Their Place in Modern Industry." He traced the development of gearing and many applications of gearing to the War, and prospects for future application were shown by him, using slides to illustrate. After the talk, the 111 members and guests visited the Western Gear Works for a field trip through their shops. The plant includes modern equipment for turning, roughing, generating, hobbing, planing, milling, shaping, grinding, heat-treating, and inspecting of all types of gearing.

West Virginia Section Has Record-Breaking Meeting

On Oct. 23 at the Daniel Boone Hotel, Charleston, W. Va., the Section held one of the most successful meetings in its history. Dr. W. C. Schroeder, chief, Office of Synthetic Liquid Fuels, Bureau of Mines, Washington, D. C., was the speaker, and his subject, "Coal Hydrogenation," was of particular interest to the process-industries region which the Section covers. The talk was built around the technological mission which Dr. Schroeder led into Germany in February of this year, to investigate the German synthetic-fuel industry. The members were greatly impressed with the speaker, and the interest he aroused, and wish to endorse him heartily for other section meetings. Members of the A.I.Ch.E. and the A.I.M.E. were guests of the Section, and an audience of 175 heard the talk, while 25 were turned away.

Worcester Section Meets With Worcester Engineering Society

A joint meeting was held on Oct. 5 with the Worcester Engineering Society. The meeting took place at the Worcester Polytechnic Institute, with an attendance of 125. The speaker, Dr. W. Trinks, member A.S.M.E., gave a talk on "Recent Work in Forging Research." He discussed types of furnaces used in heating steel for forging, the outstanding type being the induction method. Dr. Trinks spoke of his work with industry during the war, and the various problems encountered in making shells by forging. With slides to illustrate his talk, he discussed the methods used in forging the noses, such as wobbling and spinning, and the various methods of drawing, pointing out the ways of correcting the troubles.

Student Branches

University of Rochester Branch Organized in August, 1945, Enrolls 57 Members

THE first meeting of this newly formed Branch since its acceptance in the A.S.M.E. was held on October 8 in the Engineering Building. Election of officers was held for the coming semester, with the following results: Jack W. Krosse, chairman; Roy O. Ryen, vice-chairman; Karl F. Schoch, secretary, and Robert D. Hughes, treasurer. Dr. E. K. Falls was appointed honorary chairman. Under his guidance the new branch was organized in August of this year. Fifty-seven members are already enrolled.

Cooper Union Branch

The first meeting of the fall term was held on Oct. 1 in the Hewitt Building. Plans were discussed for future activities, and interesting experiences of the past summer related. Informal talks were given on such varied subjects as "The Mass Heat and Rate Flow Analyzer;" "Exhaust Equipment;" Naval Architecture;" "Machine Design;" "Torpedo Design;" "Air Replacement Equipment;" and "Refrigeration Equipment and Stability Calculations."

Illinois Institute of Technology Branch

A special meeting was held on Oct. 15 in the auditorium when Morton Spector, chairman, introduced Professor Budenholzer, honorary chairman. Professor Budenholzer gave a brief biographical sketch of the guest speaker, Dr. J. T. Rettaliata, the new chairman of the mechanical-engineering department of the Illinois Institute of Technology. Dr. Rettaliata, member A.S.M.E., who received his degrees at Johns Hopkins University, is a gas-turbine expert and was manager of the research and gas-turbine development at the Allis-Chalmers Manufacturing Company. He gave an interesting and informative talk on the gas turbine, illustrated with slides. His talk covered the historical aspects, the mechanical and design features, the thermodynamics, and the applications of the gas turbine. A discussion period followed.

Mr. Pierce, chairman of the Junior section of the Branch, spoke on the advantages of junior membership. Election of officers brought the following results; Tom Blim, president; Glen Wood, vice-president; Fred Travis, treasurer, and Eugene Tubbs, secretary.

Lafayette College Branch

The first meeting of the new term was held on Oct. 18 in the Mechanical Engineering Building. Two excellent motion pictures were shown, entitled "Steel—Man's Servant," and "Only a Gasket." Prof. Paul B. Eaton gave a talk on the functions of the A.S.M.E.

University of Maryland Branch

On Oct. 5 at the University, the Branch elected the following officers, to replace those who had been drafted: Bernard Lubarsky, president; Leslie Daly, vice-president; Roberta Flanigan, secretary. Edwin Eagleson remained in office as treasurer.

University of Michigan Branch

At the Oct. 10 meeting, in the amphitheatre of the Rackham Building, a large audience heard William B. Stout speak on "Imagineering, the Future of the Automobile." The speaker was introduced by Dean Crawford of the Engineering College. Members of other engineering societies in the University cooperated to make this a most successful meeting.

Northeastern University Branch

The annual smoker was held on Oct. 11 in room 358R with Paul Heffron, president, presiding. Prof. C. H. Wolowicz, junior member A.S.M.E., assistant professor, mechanical engineering at Northeastern University, described some of the phases of aircraft testing. A question period followed his talk. A film, loaned by the Wright Aeronautical Corporation, "The Powerhouse of Aviation" was then shown, picturing the building of engines and the maintaining of modern production methods.

On Oct. 25 a meeting was held in room 58 R. Paul Heffron, chairman, opened the session. The speaker was Robert Saumsiegle, now a student at Northeastern University, who related his experiences as a prisoner of war in Germany. He told of the many hardships and bitter misfortunes that befell him. The only contact he had with the outside world, while a prisoner, was through the American Red Cross and the Y.M.C.A., which organizations provided him with food parcels and athletic equipment, which helped sustain his morale and that of his buddies.

Northwestern University Branch

At the meeting on Sept. 28, officers for the coming term were elected as follows: A. William Eller, chairman; John M. Franks, vice-chairman; Wayne A. Neeley, secretary, and George W. Kerdolff, Jr., treasurer. Following the election, Prof. Joel Bailey, honorary chairman, gave a short talk on the merits of membership in the student branch. He also suggested that those interested in submitting a paper for the Midwest group meeting to be held in April, 1946, should start work immediately so that the papers may be presented at the meeting as a possible representation from Northwestern University. Motion pictures were shown after the talk.

Rensselaer Polytechnic Institute Branch

A joint meeting with the I.Ae.S. was held on October 4 in the Ricketts Building, with Alan Howard, member A.S.M.E., turbine division, General Electric Company, as guest speaker. Mr. Howard's subject was "The Gas Turbine and Its Application in Jet-Propelled Planes." He gave particular credit for the jet plane's successful development to Wing Commander Frank Whittle of the R.A.F.

GEORGIA SCHOOL OF TECHNOLOGY A.S.M.E. STUDENT MEMBERS AND GUESTS AT MECHANICAL ARTS BALL

(More than 600 Georgia Tech student members and guests enjoyed themselves on Sept. 22 at the A.S.M.E. Mechanical Arts Ball where overalls were the fashion. Three five-dollar prizes were awarded. Judges and winners were: *Left to right*, Henry K. Banach, student member and judge; Jesse "Windy" Renfroe, chief judge; Miss Frances Kelley, winner of best-dressed woman prize; William R. Canals, winner of best-dressed man prize; Jan Janicki, winner of greasiest-overall prize; Prof. C. R. Weeden, faculty adviser and judge; and George B. Hills, student member and judge.)

Military secrecy limited the discussion by excluding reference to specific data on plane performance, but a general picture of the jet-plane's mechanism and basic operating features was presented. Several slides were shown of jet engines and their installation in the P-59 and the newer P-80. A discussion period followed in which Mr. Howard answered several pertinent questions, among them the question as to what openings there were in this field and the rates of pay received. Mr. Howard replied that at present there was ample opportunity for men willing to take a chance on a new venture, and that the rates of pay were similar to those in other engineering fields.

University of Southern California Branch

The annual smoker was held in the Student Union Lounge on Sept. 27, with John Nash, president, presiding. Harold Davis, sales engineer, General Electric Co., gave a short talk on "Postwar Television," illustrated with a motion picture. Guests included Ray Roshong, president, Southern California Section, J. S. Earhart, vice-president of that Section, Paul Armstrong, secretary, and liaison member of the Section on the Hydraulic Division, A.S.M.E., Dr. Robert Vivian, dean of the College of Engineering, and Vincent George, honorary chairman of the Branch. Dr. Vivian gave a short talk on the wartime and postwar expansion of the College of Engineering, U.S.C.

Election of officers for the winter term was held at the Oct. 11 meeting in the Engineering Building, with the following results: James Colachis, president; Gordon Jacobs, vice-president; William Miroff, secretary-treasurer. Keys, pins, and membership cards were distributed to new members.

Tufts College Branch

A most successful meeting was held on Oct. 12 at Robinson Hall, with a large representation from the electrical, chemical, and civil engineering departments. The guest speaker was Dean Harry Burden, of the engineering school, whose subject was "Present Opportunities for the Graduating Engineer." Recent experience in placing engineers made Dean Burden well qualified to discuss this matter, and all present were impressed with the optimistic view taken by the speaker concerning their future in engineering.

At the Oct. 22 meeting in Robinson Hall, officers for the coming term were elected: E. Richard Wentling, president; Edward McNicholas, vice-president; Leroy Froeberg, secretary and treasurer. A short discussion was held on plans for future meetings. Prof. David Fisher, honorary chairman, gave a brief talk on the important part the A.S.M.E. will play in their future as professional engineers. To the graduating seniors who are nearly all naval trainees, he outlined the methods of transferring to junior membership rating once they have received their degrees.

Virginia Polytechnic Institute

The first meeting of the fall quarter was held on Oct. 15 at Patton Hall auditorium. A welcome was extended by Frank F. Fisher 3rd, president. The secretary, Glenn A. Main, Jr., and the treasurer, V. J. Moogalian, were introduced. J. L. Jones, honorary chairman, gave a brief history of the A.S.M.E. and explained its functions and ideals. The members then enjoyed a film entitled "Diesel, the Modern Power."

On Oct. 22 a second meeting was held in Patton Hall auditorium, when A. C. Seufer gave an interesting talk entitled "Production of Pig Iron in Tennessee." V. J. Moogalian spoke on "Safety in a Paper Mill." Both speakers were student members.

Villanova College Branch

On Oct. 6, Robert L. Moyer, member A.S.M.E., representative of the Hielman Boiler Works, Inc., Allentown, Pa., gave a talk on stationary high-pressure boiler design. The subject covered high-pressure-boiler tube design construction and maintenance; boiler circulation, both natural and forced; the alleviation of bad circulation in boilers already in operation; the reduction of the number of mud and steam drums to reduce weight; initial, operative, and maintenance costs; the design of boilers to the order of available cheap fuels; and the utilization of two heat sources in the furnace, i.e., pulverized coal, stoker-fed coal, fuel oil or gas-furnace gas, and Diesel exhaust.

George Washington University Branch

With the greatest turnout of students since prewar days, numbering over 200, the winter season was opened on Oct. 10 in the Government building, with the "Mixer;" Dan Aldrich, president of the G.W.U. Engineers' Council acting as master of ceremonies. Dean Feiker gave a short talk stressing the importance of human relations in engineering problems, followed by President Marvin who spoke of the special work undertaken by the University during the war period. The chairmen of the various engineering departments introduced their staffs. A scroll from the class of 1945, expressing their gratitude and appreciation for his help during their school years, was presented to Dean Feiker.

After a recess of 15 minutes to permit individual societies to hold short meetings, Bob Kemelhor, president of the Branch, opened the A.S.M.E. meeting. Twenty-six new memberships and three renewals were submitted. The "Mixer" was then called to order, and everyone enjoyed a film entitled, "This Is America."

Washington University Branch

The first meeting of the fall semester was held on Oct. 18 in Brown Lounge on the campus. Prof. Raymond R. Tucker, honorary chairman, head of the mechanical-engineering department at the University, opened the meeting with a brief talk. A technicolor film "Unfinished Rainbows," product of the Aluminum Company of America, was shown; this depicted the story of aluminum. New officers installed were: Melvin Franzel, chairman; Paul Tandler, vice-chairman; Wing Leong, secretary; George Palcheff, treasurer.

A.S.M.E. Receives Report on Orinoco-Casiquiare-Negro Waterway

THE Office of Inter-American Affairs has presented to The American Society of Mechanical Engineers two copies of a report on the Orinoco-Casiquiare-Negro Waterway in four volumes (1) Text and Drawings, (2) Photographic Record, (3) Maps and Profiles, and (4) Appendix.

The report was financed by the Office of the Co-Ordinator of Inter-American Affairs and the survey was made by the Corps of Engineers, U. S. Army. The report has been deposited in the Engineering Societies Library.

Engineering Societies Personnel Service, Inc.

These items are from information furnished by the Engineering Societies Personnel Service, Inc., which is under the joint management of the national societies of Civil, Electrical, Mechanical, and Mining and Metallurgical Engineers. This Service is available to members and is operated on a co-operative, nonprofit basis. In applying for positions advertised by the Service, the applicant agrees, if actually placed in a position through the Service as a result of an advertisement, to pay a placement fee in accordance with the rates as listed by the Service. These rates have been established in order to maintain an efficient, nonprofit, personnel service and are available upon request. This also applies to registrants whose notices are placed in these columns. All replies should be addressed to the key numbers indicated and mailed to the New York office. When making application for a position include six cents in stamps for forwarding application to the employer and for returning when necessary. A weekly bulletin of engineering positions open is available to members of the co-operating societies at a subscription of $3 per quarter or $10 per annum, payable in advance.

New York	Chicago	Detroit	San Francisco
8 West 40th St.	212 West Wacker Drive	109 Fansworth Ave.	57 Post Street

MEN AVAILABLE[1]

MECHANICAL ENGINEER, 30, M.E. degree, desires position as service engineer with recognized company manufacturing mechanical equipment or aircraft. Six years' experience as methods engineer, designer and service engineer. Either domestic or foreign travel satisfactory. Me-956.

ENGINEERING EXECUTIVE OR ASSISTANT, mechanical engineer, 52, twenty-seven years' varied experience in advertising, sales promotion, research, cost analysis, scheduling, inventory control, procurement. Compiled handbooks and instruction manuals. Salary, $7500 year. New York Area. Me-957.

MECHANICAL ENGINEER, 30, married. Seven years' responsible experience in design, operation, and maintenance of process steam-power plant and chemical plant. Currently in charge of maintaining high-pressure power station. Me-958.

REGISTERED MECHANICAL ENGINEER, 30, college graduate. Three years' pipe-line-maintenance experience and four years' shipyard work as naval officer. Desires position in Florida. Available December 1, 1945. Me-959.

MECHANICAL ENGINEER, graduated 1939. Experienced in design, production, maintenance, and operation of small mechanical and electrical devices. B-29 flight engineer for two years. Desires position as assistant shop superintendent. Me-906.

MECHANICAL ENGINEER, 31, married. Eight years' diversified experience traffic engineering, materials testing, marine piping and power units. Desires permanent position (test and development) with future. Location, near New York, N. Y., or Washington, D. C., preferred. Me-961.

INDUSTRIAL ENGINEER, graduate, married, over eleven years' broad industrial engineering experience in manufacture of mechanical cooling equipment. Desires responsible position with progressive concern. East preferred. Me-962.

INDUSTRIAL ENGINEER, B.S., married, 29, eight years' experience in industrial engineering and in dealing with labor problems. Desires supervisory or administrative position with small or medium company. East Coast preferred. Me-963.

MECHANICAL ENGINEER, 34, experienced in steam-power plant and refrigeration design, installation, and maintenance, shop and engine repair; some medium machine design. Interested in connection with chemical or process plant. Me-964.

MECHANICAL ENGINEER, 38, sixteen years' wide and responsible administrative experience in product testing, quality control, and liaison work between consumer and sales representatives, desires connection in sales-engineering field. Me-965.

GRADUATE MECHANICAL ENGINEER, 29, married, good health. Separated from Army after four years' experience in test of automotive ordnance. Desires to be assistant in any phase of mechanical engineering. Me-966.

MECHANICAL ENGINEER, 30, M.I.T. graduate, eight years' experience in designing, tooling, and production methods, desires position with progressive medium-sized firm, as head of production or production control. Location immaterial. Me-967.

MECHANICAL ENGINEER, B.S., M.S., 32; successful administrative and development experience. Specialist in vibration problems; some experience in electrical engineering. Desires position as project or development engineer with company having new products. Me-968.

ADMINISTRATOR-MANAGER, Mechanical Engineer. Now vice-president large corporation seeks new connection with manufacturer. Exceptional ability as organizer, production supervisor, personnel, and publicity. Prefer New York, N. Y. Recently U. S. Navy. Me-969.

GRADUATE MECHANICAL ENGINEER, 36, eight years' experience design and development of rubber-working machinery. Three years' general production experience. Desires connection in equipment design and development or as project engineer. Me-970.

SERVICE ENGINEER, married, 30, M.E., desires position as assistant chief or test engineer in power plant. Experience power-plant tests and operation oil, pulverized coal, black liquor boilers. East preferred. Me-971.

EXECUTIVE ENGINEER, graduate, 43, assume full responsibility as production manager, plant superintendent, or chief engineer, twenty-three years' diversified practical, design, and executive experience. Specialized in precision manufacturing, instruments, tools, fixtures, precision-gear manufacturing, cost control, inspection, assembly, plant engineering. Excellent record to get things done. Me-972.

MECHANICAL ENGINEER, 27, desires design and development work on small mechanisms. Past three and a half years investigated and corrected design difficulties encountered during production. Mechanisms conceived are now used in aircraft engines. Me-973.

SALES ENGINEER, mechanical engineering graduate, with established Midwest contacts. Experience in sales, sales promotion, machining, heat-treating, and metallurgy. Desires position as sales engineer in steel, castings, or forging sales. Me-974.

[1]All men listed hold some form of A.S.M.E. membership.

POSITIONS AVAILABLE

PLANT ENGINEER, 35–45, mechanical or mining graduate, with chemical-process experience, take charge mineral machinery and chemical-plant equipment. $5000–$6000 year. Southwest. W-6091.

PLANT ENGINEER, under 40, mechanical graduate preferred, take charge of maintenance and construction additions to paper mill. $4800 year. Southeastern U. S. W-6101.

PLANT ENGINEER, mechanical graduate, married, who has held responsible position in manufacturing plant producing chemicals or allied products such as oils, pigments, etc., for small plant producing chemicals. Will have to correspond with prospective suppliers of machinery and equipment and direct draftsmen in plant layouts, check calculations, etc. Starting salary to $6000 year. Location, Virginia. W-6114.

CEMENT PLANT ENGINEERS OR OPERATORS to rehabilitate about a dozen cement plants. $7200–$8100 year. Manchuria for 6 to 18 months, then possibly United States. W-6137.

ENGINEERS for medium-sized machine manufacturing plant. (*a*) Test plant and field engineer with experience in erection and operation heavy mining and process machinery. Must have ability to meet and handle many classes of people. Permanent. Some traveling. (*b*) Test plant and laboratory assistant, under 30, knowledge of chemistry and physics. Must be skilled in handling tools. (*c*) Sales and service engineer, under 30, technical training. Must be willing to work at anything with ultimate goal of selling heavy machinery. (*d*) Designing engineer. Must have experience in structural and machine design of heavy process machinery. Permanent. Pennsylvania. W-6138.

INDUSTRIAL ENGINEER, 35–50, good industrial-engineering experience and some sales experience, to specialize in sale of industrial-engineering services for well-established firm. Will be required to set up own program and carry it through. Prefer man who resides in New York, New Jersey, or Connecticut area. $6000–$8000 year. Headquarters, New York, N. Y. W-6154.

ENGINEERS, graduates preferred, under 40, management-engineering experience in steel

field or who have had staff experience in more than one location involving design and installation of production-control systems, to work either in systematizing capacity or in work involving administration of production planning. Up to $6000 year. Pennsylvania. W-6185.

INSTRUCTORS, 2, of mechanical engineering. One should be thoroughly versed in heat transfer, heat power, and refrigeration and have knowledge of thermodynamics. Should have some teaching experience and be familiar with electronic instrumentation as applied to mechanical engineering. The other should be trained in field of design and know advanced strength of materials, vibrations, elasticity, and stability as applied to machines. Experience in teaching drawing, descriptive geometry, kinematics or machine design desirable. Pennsylvania. W-6189.

PROFESSORS. (*a*) Associate or full professor, D.S. or Ph.D. degree, under 40, to direct work in materials-testing laboratory and develop metallurgical laboratory to be coordinated with it. (*b*) Associate professor of industrial engineering, about 40, who has had experience in executive work in industry and who is familiar with modern problems of management. (*c*) Professor of electrical engineering, about 40, Ph.D. degree, who is specialist in electronics and qualified to become head of department in near future. Salaries depending upon qualifications. Upstate New York. W-6195.

ENGINEERS. (*a*) Design engineers, eight to ten years' experience on small interchangeable-parts design. Must be capable of checking complete drawings. Any electrical experience would be helpful. $5000–$6000 year. (*b*) Material and process engineer, preferably with some experience on plastic materials and finishes. Experience as expeditor with knowledge signal corps helpful. $4000–$5000 year. New York metropolitan area. W-6208.

METHODS ENGINEER, mechanical graduate, at least five years' experience in machine shop, preferably on small parts and with knowledge of jigs, fixtures, production tools, test equipment, etc. New York metropolitan area. W-6210.

ENGINEERS. (*a*) Industrial Engineer, 30–40, graduate. Must be clerical expert. Work involves time motion study, clerical incentives, base rates, etc. Must have considerable experience in clerical savings through form design and clerical method short cuts, setting of standards. (*b*) Works executive, 30–40, graduate accountant. Should have done outstanding work in organization administration in works' accounting field. Should be recognized as one who can make his own contributions in management to a company. Training in company work will be provided. Salaries open. Ohio. W-6219D.

SUPERVISING ENGINEER, wide experience in industrial plants, take complete charge of power plants, mechanical and electrical equipment, and construction activities. $14,000 year. Massachusetts. W-6221.

DIRECTOR OF RESEARCH, 35–45, for company manufacturing small electromechanical machines. Should be able to direct work of number of research and development assistants. $15,000 year. New York metropolitan area. W-6234.

ENGINEERS. (*a*) Test Engineer, M.S. degree and laboratory experience desirable, take charge commercial and industrial structures and materials tests. Opportunity to work for doctorate. About $3900 year, one month vacation with pay. (*b*) Research engineer, electrical, mechanical, or civil degree and some experience materials testing and vibration theory desirable, to work on industrial research program. About $3000 year. (*c*) Research Fellows to work half time on industrial research programs and study half time for M.S. or Ph.D. degree. $1080 year, together with freedom from tuition fees. Summer work available. Pennsylvania. W-6249.

FACTORY MANAGER for plant employing 400 to 500 people engaged in manufacture small electrical products, i.e., stampings, assemblies, etc. $7500–$8500 year. Ohio. Interviews, New York, N. Y. W-6251.

PRODUCTION MANAGER, 35–40, engineering graduate preferred, to reorganize and operate combination of production control and order departments which are now separate. Take charge inventory control, time-keeping, and production planning. Will work closely with sales department and be responsible for scheduling deliveries to customers; aid general manager. $6000 to $7000 year. East. W-6253.

MECHANICAL ENGINEER, young, for design and development work on power-transmission equipment, preferably some knowledge of foundry and machine-shop practice. Pennsylvania. W-6255.

A.S.M.E. Sections

Coming Meetings

Baltimore. January 28. Engineers' Club of Baltimore at 8:15 p.m. Subject: "Gas Turbines for Transportation Applications," by Prof. J. I. Yellott, director of research, Locomotive Development Committee, Baltimore.

Boston. December 13. Northeastern University at 8:00 p.m. Subject: "Ship Propulsion Dealing With the Utilization of Power in Connection With Ship Propulsion," by J. P. Den Hartog, professor, mechanical engineering, Massachusetts Institute of Technology.

Central Illinois. December 13. Subject: "Magnesium," by Dan W. Moll, vice-president, Hills-McCanna Co., Chicago, Ill.

Chicago. December 18. Sixth floor, Little Theatre, Civic Opera Building, at 7:30 p.m. Subject: "Time and Motion Study as a Means of Increased Productivity," by James S. Perkins, chief of personnel and results, Western Electric Company.

December 13. Junior Engineers' Seminar.

Minnesota. December 11. Coffman Memorial Union, University of Minnesota. Subject: "Made in U. S. A." a film by the Minneapolis Moline Implement Co.

North Texas. December 21. Stoneleigh Hotel, Dallas. 6:30 p.m. Christmas Party.

Ontario. December 13. Hart House. Subject: "Motor Selection," by J. D. Duncan.

Candidates for Membership and Transfer in the A.S.M.E.

THE application of each of the candidates listed below is to be voted on after December 24, 1945, provided no objection thereto is made before that date, and provided satisfactory replies have been received from the required number of references. Any member who has either comments or objections should write to the secretary of The American Society of Mechanical Engineers immediately.

KEY TO ABBREVIATIONS

Re = Re-election; Rt = Reinstatement; Rt & T = Reinstatement and Transfer to Member.

NEW APPLICATIONS

For Member, Associate, or Junior

ABBATIELLO, ANTHONY A., Teaneck, N. J. (Rt & T)
ANGEMEER, CHARLES W., Finleyville, Pa.
BAHR, JOHN L., Yorklyn, Del.
BAINBRIDGE, HAROLD, Trenton, N. J.
BALTZELLE, LEE C., Seattle, Wash.
BARRY, JOHN S. C., Pawcatuck, Conn.
BATES, C. W., Ingleside, Texas
BICHART, FRANKLIN R., Harpursville, N. Y.
BOOTH, JOHN G., Philadelphia, Pa.
BOSCH, LESTER L., Washington, D. C.
BROWN, GRAHAM B., Youngstown, Ohio
BRUMFIELD, R. C., Hollywood, Calif.
BURNITE, A. W., Wilmington, Del.
BURNS, ALEXANDER, Bronx, N. Y.
BUTTKE, RICHARD A., Milwaukee, Wis.
CALKINS, R. G., Akron, Ohio
CARLSON, R. O., Charleston, W. Va.
CHAMBERLAIN, JOSEPH B., Worcester, Mass.
CHIVINSKI, JOSEPH RICHARD, Reading, Pa.
CIAVARELLA, PETER J., Chicago, Ill.
CLARK, WILLIAM L., JR., Toledo, Ohio
COLWELL, A. WARREN, Milwaukee, Wis.
COOKE, JAMES W., Villanova, Pa.
COVINGTON, WAYNE R., Seattle, Wash.
CRAWFORD, ALFRED RUSSELL, Bridgeton, N. J.
CROWELL, SERGE L., New York, N. Y. (Rt & T)
CYRIACKS, JOHN, Westerley, R. I. (Rt & T)
DARMODY, WILLIAM J. (LIEUT. COL.), Philadelphia, Pa. (Rt & T)
DAVENPORT, CHARLES C., Media, Pa.
DELLIS, P. L., New York, N. Y.
DEW, JAMES A., JR. (LIEUT.), San Francisco, Calif.
DICKINSON, JAMES P., Binghamton, N. Y.
DIETER, GEORGE H., Los Angeles, Calif.
DIETSCH, A. J., Hingham, Mass.
DIMATTEO, J. E., Jersey City, N. J.
DINIC, CARL J., New York, N. Y.
DIXON, J. K., Milwaukee, Wis.
DONEY, WILLIAM L., Pittsburgh, Pa. (Rt)
DURLACH, MARCUS R., JR., Malverne, N. Y. (Rt & T)
EISENBEIS, GEORGE G., Binghamton, N. Y.
EMERY, R. W., Toronto, Ontario, Canada
EN DEAN, HOWARD J., Pittsburgh, Pa.
EPPENS, ERNEST G., Phillipsburg, N. J.
ERZER, JOHN K., Erie, Pa.
FIDELI, FRANZ ANTON, Coytesville, N. J.
FISHER, JOHN C., Cambridge, Mass.
FLICKINGER, JOHN H., Marblehead, Mass.

FRANKLIN, GEORGE McCARTY, Dallas, Texas
FRESTON, ROBERT B., Oak Park, Ill.
GEHRIG, E. J., Evanston, Ill.
GLINSKE, EDWARD J., JR., Philadelphia, Pa.
GOIN, NEWBOLD C., Pittsburgh, Pa.
GOLDER, J. D., Wadsworth, Ohio
GOOD, R. S., Jeannette, Pa.
GRAHAM, DALLAS P., Columbus, Ohio
GREENE, N. B., Guilford, Conn.
GREENE, RICHARD S., Montclair, N. J.
GRUNER, FREDERICK R., Milwaukee, Wis.
HABIG, WILLIAM A., Livingston, N. J.
HAMBLETON, H. B. (COL.), Washington, D. C.
HART, HERMAN A., Dallas, Texas
HATFIELD, C. M., Elizabethton, Tenn.
HAYS, FRANK B. (COMDR.), Arlington, Va.
HERMES, R. M., Santa Clara, Calif.
HILL, WILLIAM J. (SGT.), San Francisco, Calif.
HOGAN, JOHN J., White Plains, N. Y.
HOTCHKISS, C. F., Binghamton, N. Y.
HUMISTON, H. A., Cleveland, Ohio
HUTCHINGS, ALBERT R., Wellesley Hills, Mass.
HYDE, E. B., JR., Flushing, N. Y.
IRONS, D. E., Solvay, N. Y.
JENNINGS, JAMES H., Fort Wayne, Ind.
JULSON, JEWELL ORVIN, Plattsburg, N. Y.
KASTLE, C. M., Charleston, W. Va.
KOFFER, G. WARREN, E. Pittsburgh, Pa.
LABASTIE, ALBERT H., Belmont, Mass.
LABRIE, THEODORE JOSEPH (ENSIGN), Brooklyn, N. Y.
LAMM, O. DELL, Lebanon, Pa.
LEEMAN, E. R., Johannesburg, S. A.
LIANG, Y. C., Coventry, England
LINDAHL, ROBERT L., New York, N. Y.
LORING, SAMUEL J., Stratford, Conn.
LUDWIG, ERNEST T., Thurgau, Switzerland
MACCRACKEN, C. D., New Rochelle, N. Y.
MADDOX, A. W. (COMDR.), Washington, D. C.
MAO, EASIN, Washington, D. C.
MARLATT, CHARLES M., Akron, Ohio
MARR, JOHN H., Milton, Mass.
MARSHALL, HUGH A., New York, N. Y.
MARTIS, JEROME M., Wilkes Barre, Pa.
McANDREW, ROBERT GAVIN, JR. (LIEUT.), Johnstown, N. Y.
McCABE, WARREN L., Pittsburgh, Pa.
McCLELLAN, DONALD E., Detroit, Mich.
McCLELLAND, JAMES E., Fond du Lac, Wis.
McCONNELL, JAMES A., Rochester, N. Y. (Rt & T)
McCUMBER, RALPH H., Rochester, N. Y. (Rt & T)
McDANIEL, WEYMOUTH N., Dundalk, Md.
McDONALD, JOSEPH J., Bremerton, Wash.
MELARA, PHILIP, St. Albans, N. Y.
MOOREHOUSE, G. W., Oak Ridge, Tenn.
MORGAN, MRS. C. L., Chicago, Ill.
MORRISON, T. J., Compton, Calif.
MORSE, HAROLD L., Columbus, Ohio
NEUMANN, ERNEST P., Belmont, Mass.
NEWMAN, WILLIAM A., Montreal, Quebec
NICHOLLS, M. B., Cincinnati, Ohio
NICHOLS, CLAYTON F., Bremerton, Wash.
NICK, EDWIN W., Erie, Pa.
NORCROSS, GILBERT F., W. Caldwell, N. J.
OLIND, JOHN H., SR., Buffalo, N. Y. (Rt & T)
PETERSEN, CHARLES A., Erie, Pa.
PFEIFER, OTTO JOHN, JR., Minneapolis, Minn.
PICKEL, WILLIAM F., Wilmette, Ill.
PLESSER, JOSEPH JAMES, Brooklyn, N. Y.
POSSNER, LOUIS, Berkeley, Calif.
PRINCE, WILLIAM (LIEUT.), Middle River, Md.
QUERY, LEO H., Rochester, N. Y.
RAFALOW, JULES, New York, N. Y.
REEVE, W. A., Trenton, N. J.
REIBER, H. P., Milwaukee, Wis. (Rt)
ROPER, CHARLES G., Fairfield, Conn. (Rt & T)
ROSENGARTEN, GEORGE M., South Charleston, W. Va.
SAALFRANK, ROYAL BARTLETT, Philadelphia, Pa. (Rt & T)
SALSIG, WILLIAM WINTER, JR., Berkeley, Calif.
SCHOESSOW, EARL E., Barberton, Ohio
SHERRIN, KENNETH J., Oak Ridge, Tenn.
SILHA, HENRY WILLIAM, Moscow, Idaho
SLAMER, DON C., Des Plaines, Ill.
SMITH, JACOB S., Peoria, Ill.
SMITH, JAMES W., Akron, Ohio
SYNDENNIS, E. J., New Brighton, Staten Island, N. Y.
TICOTSKY, MATTHEW E., New Haven, Conn.
TREFETHEN, L. S., Rochester, N. Y.
TROUT, CHARLES L., Upper Darby, Pa.
VAN AUKEN, HOWARD C., Manhasset, N. Y. (Rt & T)
VONDERSMITH, EARL L., Bryn Mawr, Pa.
WILKINS, CHARLES N., Glenside, Pa. (Rt)
WOODS, ROBERT H., Milwaukee, Wis.
YOUNG, DONALD A., New York, N. Y.
YOUNG, EINAR T., Washington, D. C.
YOUNKIN, G. S., Pasadena, Calif.
ZIMMERMAN, MILTON JOSEPH, San Antonio, Texas

CHANGE OF GRADING

Transfers to Member

ACKERMAN, WILLIAM L., Peoria, Ill.
ALEXANDER, WILLIAM T., Boston, Mass.
ANDERSEN, HENRY C., Wakefield, Mass.
BARATTA, HENRY E., Plainfield, N. J.
BAUER, CHARLES A., Evansville, Ind.
BECKWITH, T. G., Pittsburgh, Pa.
BENTEY, THOMAS, East Orange, N. J.
BIALOG, EDWARD S., Brooklyn, N. Y.
BROOKS, F. WARREN, Cleveland, Ohio
BROWN, RICHARD R., New York, N. Y.
BROWNE, W. H., Columbus, Ohio
CHERRY, L. H., Santa Fe, N. M.
COLBY, ELMER W., Grand Rapids, Mich.
DEXTER, H. W., JR., Pittsburgh, Pa.
ELLIOTT, EDWARD, JR. (MAJOR), Washington, D. C.
ESHELMAN, RODNEY L., Belle, W. Va.
EVERETT, RUSSELL W., Roselle Park, N. J.
FARR, M. S., Los Angeles, Calif.
GREELEY, CHARLES E., Ada, Minnesota
HIRT, JOHN H., Los Angeles, Calif.
HOLT, CLIFFORD C., Independence, Mo.
LUCKING, WALTER T., Wheeling, W. Va.
MASON, F. C., Fort Wayne, Ind.
MORRIS, GLENN L., Chattanooga, Tenn.
NICHOLAS, SERAFIM, New York, N. Y.
NICHOLS, DE OWEN, JR., Detroit, Mich.
O'CONOR, FRANK, Moline, Ill.
PANITZ, KARL A., Johnson City, N. Y.
PARRISH, JOSEPH R., Knoxville, Tenn.
PATTISON, R., Durban, S. A.
PETURA, FRANK E., Scotch Plains, N. J.
ROUSHEY, RAY E., Dushore, Pa.
PROBST, JOSEPH R., Waynesboro, Va.
REINHARDT, RICHARD G., Mascoutah, Ill.
RISLEY, D. L., E. Cleveland, Ohio
SCOTT, F. WILLIAM, Atlanta, Ga.
SHAW, JOHN F., Whittier, Calif.
THOMPSON, E. S., Marblehead, Mass.
TRANSOU, ADAM J., Bayonne, N. J.
TRUMAN, FREDERICK, Toronto, Ontario
VANDEGRIFT, C. G., State College, Pa.
VAN VALKENBURGH, R. M. (CAPT.), Philadelphia, Pa.
WEBB, BAXTER, Detroit, Mich.
WELLS, GORDEN S., Binghamton, N. Y.
WHITSON, LEE S., Minneapolis, Minn.
WIITANEN, W. W., New York, N. Y.

Transfers from Student Member to Junior 65

A.S.M.E. Transactions for November, 1945

THE November, 1945, issue of the Transactions of the A.S.M.E. contains:

Heat Transfer From a Baffled-Finned Cylinder to Air, by A. W. Lemmon, Jr., A. P. Colburn, and H. B. Nottage

Local Coefficients of Heat Transfer for Air Flowing Around a Finned Cylinder, by W. H. Mc Adams, R. E. Drexel, and R. H. Goldey

Efficiency of Extended Surface, by K. A. Gardner

Tube Spacing in Finned-Tube Banks, by S. L. Jameson

A General Correlation of Friction Factors for Various Types of Surfaces in Crossflow, by A. Y. Gunter and W. A. Shaw

Air-Cooled Steam Condensers, by R. A. Bowman

Heat Transfer Through Tubes With Integral Spiral Fins, by D. L. Katz, K. O. Beatty, Jr., and A. S. Foust

Heat Transfer and Pressure Loss in Small Commercial Shell-and-Finned-Tube Heat Exchangers, by R. M. Armstrong

Heat-Transfer Coefficients and Other Data on Individual Serrated-Finned Surface, by E. A. Schryber

Disk Extended Surfaces for High Heat-Absorption Rates, by G. E. Tate and John Cartinhour

Heat-Flux Pattern in Fin Tubes Under Radiation, by A. R. Mumford and E. M. Powell

Heat Transfer and Pressure Drop of Liquids in Double-Pipe Fin-Tube Exchangers, by B. De Lorenzo and E. D. Anderson

Numerical Methods for Transient Heat Flow, by G. M. Dusinberre

An Electrical Geometrical Analogue for Complex Heat Flow, by C. F. Kayan

Necrology

THE deaths of the following members have recently been reported to headquarters:

APPS, CHARLES H., September 29, 1945
BERTUCH, PAUL N., April 12, 1945
CASSIDY, PATRICK F., November 17, 1944
DAVIDSON, HOBART O., September 22, 1945
DOWD, BERNARD J., September 19, 1945
FOSTER, CLARK H., September 11, 1945
GERNGROSS, FREDERICK J., July 30, 1945*
GOUDIE, WILLIAM J., October 4, 1945
HARPER, ROBERT G., October 8, 1945
HILL, WILLIAM, August 26, 1945
HOWARD CECIL D., September 14, 1945
JOHNSON, WERNER, October 3, 1945
KEIFER, BOYD E., July 25, 1945
LOCKETT, ANDREW M., October 11, 1945
LUDLOW, G. RICHARD, September 14, 1945
ROWELL, WEBSTER H., January 8, 1945
SCHUERMAN, OTTO E., December 18, 1944*
SPENCER, ROBERT L., October 10, 1945
TAYLOR, ALFRED J. T., July 19, 1945
WERME, ANDREW P., August 13, 1945
ZOHE, L. ALVIN, September 22, 1945

* Died in line of duty.

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Announcements in this section are supplied by current advertisers in MECHANICAL ENGINEERING and A.S.M.E. MECHANICAL CATALOG.

This section is restricted to these advertisers.

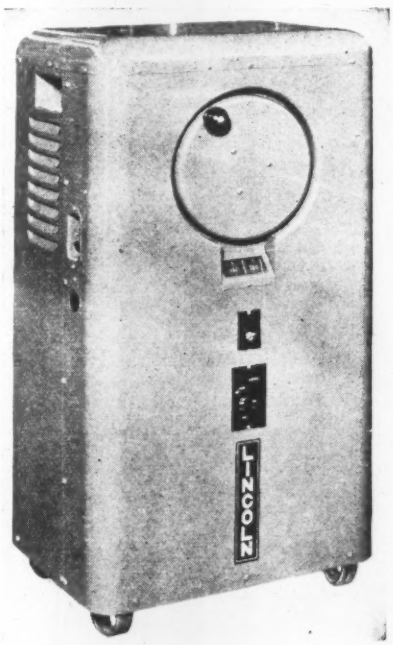
• NEW EQUIPMENT
• BUSINESS CHANGES
• LATEST CATALOGS

Available literature may be secured by addressing a request to the Advertising Department of MECHANICAL ENGINEERING or by writing direct to the manufacturer and mentioning MECHANICAL ENGINEERING as a source.

• NEW EQUIPMENT

Lincoln Announces New Low-Priced Welder for Farm and Shop Use

A new low-priced welder which is ideal for rural power lines and is said to overcome all the objectionable features of previous welders designed for this type of service has just been announced by The Lincoln Electric Co., Cleveland, Ohio.



The new unit, called the "Fleet-Arc Jr.," is for 230 volt, single phase power lines and meets the limited input requirements of rural Utilities and REA by a design of high efficiency and high power factor. It has a maximum input current of 35 amperes and provides a machine which meets the new NEMA standards for this type of welder. It can be used with the standard 3-KVA power transformer provided by the power company. Current range is from 20 amperes at 20 volts to 180 amperes at 25 volts welding duty. This gives sufficient capacity for all types of jobs found on most farms or job welding shops. It will handle electrodes ranging from $^1/_{16}$" to $^5/_{32}$" diameter.

The "Fleet-Arc Jr." which simplifies welding and multiplies its utility for repair and fabricating jobs done by farmers and average mechanics, inaugurates a revolutionary development known as the "Arc Booster" which provides quick, easy arc starting. The instant the electrode touches the work, the welding current is given a boost of intensity for starting the arc.

The current then reverts automatically to the amount set for the job. No high voltages or special high frequency devices are used, the output voltage being limited to a maximum of 52 volts.

Either of the two degrees of arc boosting provided is selected by a snap switch, one for general work and the other lower amount for thin material such as automobile fenders.

Current control for the new "Fleet-Arc Jr." is of the separate adjustable reactance type which is varied by turning a hand wheel. Adjustment is continuous over entire welder range of from 20 to 180 amperes.

Design and construction features of the new welder include:

Wear-free and vibrationless reactor current control with self-cleaning chain drive. No taps or plugs to develop loose connections.

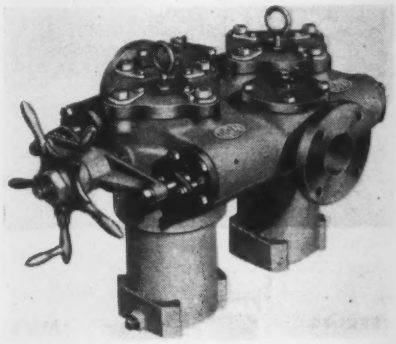
Heavy copper winding with spun glass insulation and mica coil separators. Arc welded steel frame and housing.

"Fleet-Arc Jr." weighs only 360 pounds and is, therefore, readily portable.

Full information can be obtained by addressing The Lincoln Electric Co. at Cleveland, Ohio.

Disc Type Pipeline Strainer

A duplex vertical chamber disc type pipeline strainer has been designed to assure continuous flow in pipelines, and is operated by a large handwheel that reverses valves simultaneously with minimum pressure drop. Capacity flow is assured at all positions of the operating handwheel.



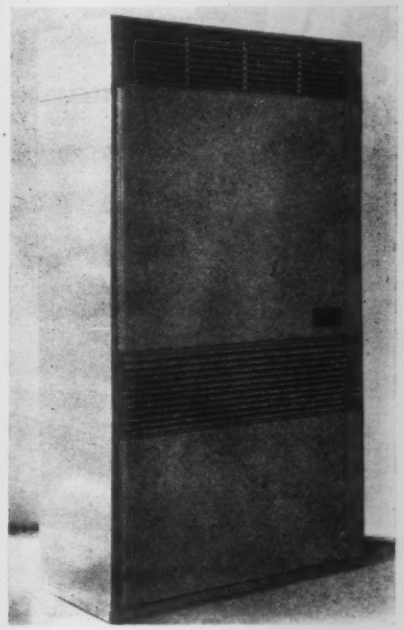
Another unusual aspect is the eccentrical postion of the strainer basket, with respect to the basket chamber, so that the flow section is proportional to the flow needs at all points, thus minimizing pressure drop. The usual practice of setting the strainer basket concentrically creates a fluctuating flow of liquids in regard to flow needs, thus stimulating fluid friction loss.

Removable covers provide easy access to the basket chamber and permit easy and complete cleaning. Large handholes above each valve assembly permits servicing of the valves without removing the strainer.

This unit protects all types of pumps, traps, valves, regulators, asperators, injectors, control units and other primary equipment. It is made in cast bronze, steel, semi-steel, and cast iron; the basket, of perforated brass, monel, or other specified metals. Manufactured by J. A. Zurn Mfg. Co., Erie, Pa.

New Worthington Air Conditioning and Refrigeration Equipment

Plans are now complete to turn a large part of the heavy ordnance manufacturing facilities of the Worthington Pump & Machinery Corp.'s Plant in Holyoke, Mass., into production of air conditioning and refrigeration equipment of the latest design. Facilities for the operation have been moved there from the corporation's plant in Harrison.



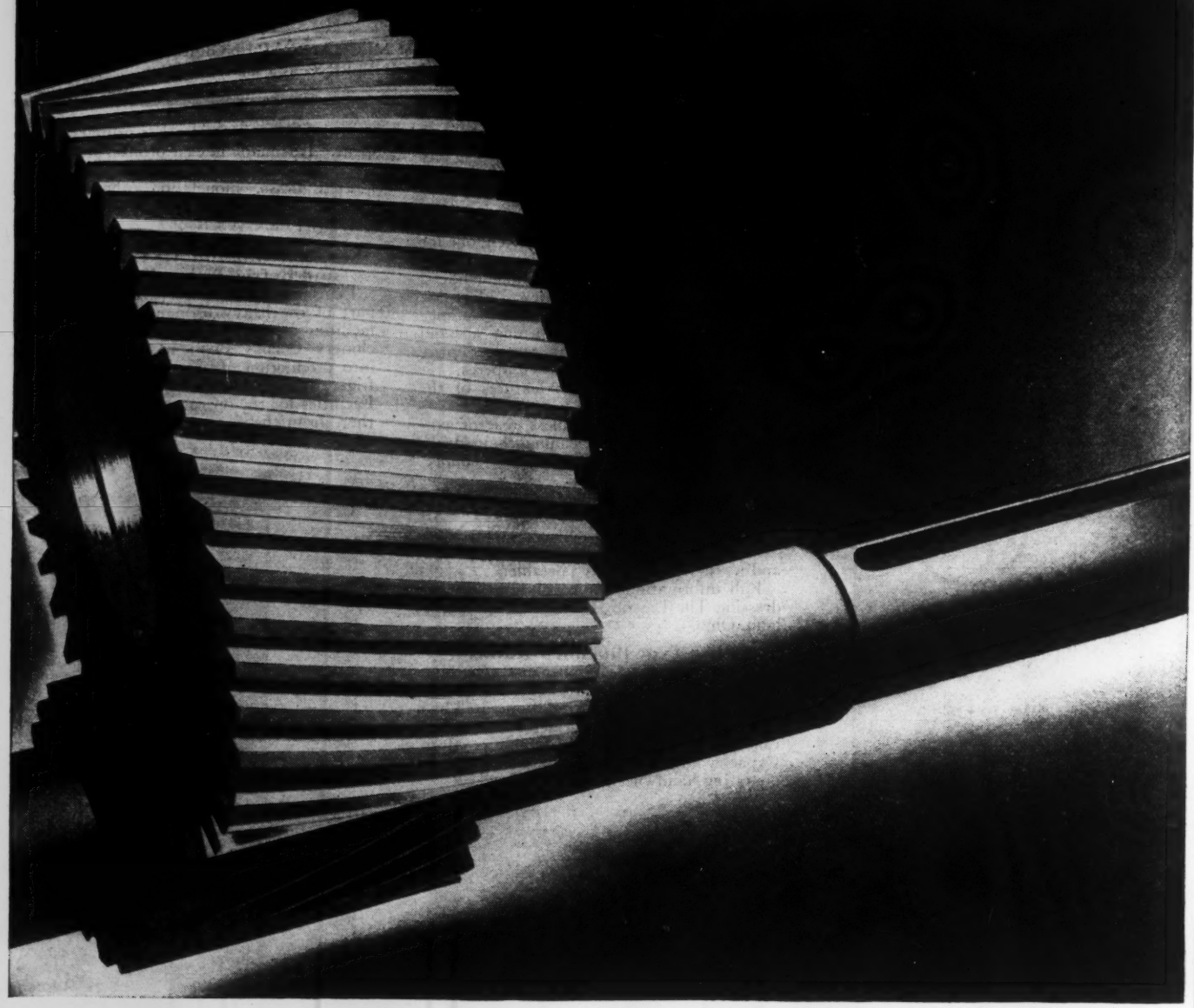
Engineers are concluding designs for a new line of Freon-12 refrigerating compressors. Also to be produced at Holyoke will be a line of air handling equipment including air conditioning units, shower condensers, product coolers, and evaporative coolers in a wide range of sizes and capacities.

Fred J. Riedel, chief engineer, has installed one of the most complete test laboratories for refrigeration equipment in the country. Assembly line methods have been set up in the same shop where thousands of 90 mm. anti-aircraft guns were produced in the early part of the war.

Sales headquarters will also locate in Holyoke, with W. F. Bishop, Assistant Manager of the division in charge. The heavy industrial equipment is still being made in Harrison. The company's Air Conditioning and Refrigeration operation is

Continued on Page 39

Molybdenum gives steel the strength and toughness necessary to make long-lived gears.



CLIMAX FURNISHES AUTHORITATIVE ENGINEERING DATA ON MOLYBDENUM APPLICATIONS.

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500 Fifth Avenue • New York City

MOLY

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under the management of C. E. Wilson, Vice President of the Corporation and M. M. Lawler, Manager of the division.

Riedel will be assisted by J. Neuhoff, Engineer in Charge of Air Conditioning Units Design, and L. J. Hall, Engineer in Charge of Application.

Tough Turbines

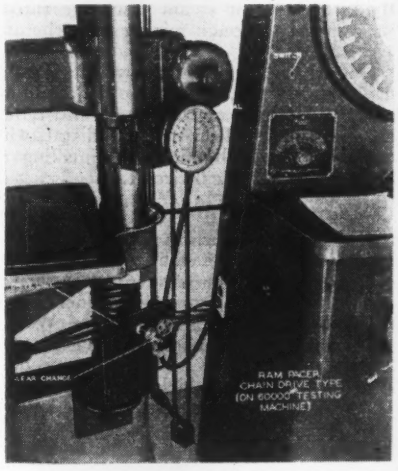
Engineers and workmen of the Westinghouse steam-turbine division at South Philadelphia, Pa., had two reasons to feel proud last month. Both had to do with U. S. aircraft carriers for which they had designed and built the propulsion equipment.

The carrier Hornet, her bow and flight deck damaged by a typhoon, had to back into the wind at 20 knots in order to get her planes in the air. Although the Navy had specified to Westinghouse turbine and gear engineers that the machinery be able to drive the 27,000 ton flattop backwards at high speed for an hour and a half, no real battle test was ever encountered. When a raging typhoon set the stage, the carrier turned the trick several times without serious overheating of the turbine blades that must turn backwards during astern operation.

The Essex, prototype of the 24 carriers for which Westinghouse designed and built the propulsion equipment, set a remarkable distance record during the war. She covered a quarter of a million miles of ocean, averaging 250 miles for every day since commissioning, including days in port. Over this distance—more mileage than would normally be expected in the life of a capital fighting ship—her turbine and gears never required more than routine maintenance.

Southwark Ram Pacer

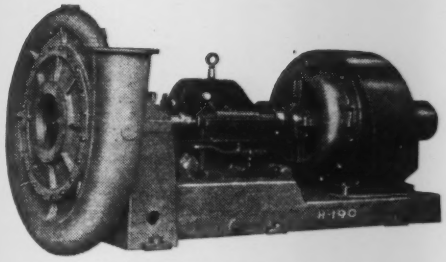
In testing metals, plastics and woods many specifications require that the loads be applied at certain and exact speeds. To date this control has been difficult to obtain as no simple, fully automatic and satisfactory pacing device has been available. To fill this important need as engineers and designers work in preparing their new products, often with new materials, the Southwark Division of the Baldwin Locomotive Works has developed the Southwark Ram Pacer.



The new device, which attaches to a standard hydraulic testing machine, gives control over the crosshead movement at eight preset speeds, .01, .02, .05, 0.1, 0.2, 0.4, 0.5 and 1.0 inches per minute. These speeds are obtained by gear changes on the synchronous motor drive unit. This unit is attached to the fixed frame of the machine while the dial

Continued on Page 40

• Without air blast, we'd have no iron or steel. Vast amounts are whirled by blowers to blast furnaces, Bessemer converters and foundry cupolas. Air is equally important in heat-treating, annealing and other manufacturing processes.



Whether you need the 17,000 CFM which this centrifugal blower delivers, or only 10 CFM, Roots-Connersville can supply it from either standard or specially designed units. Ask for details.

Acceptance of Roots-Connersville blowers by the iron and steel industry dates back almost a century to our inception of the first rotary positive blowers. Our centrifugal blowers and exhausters are also widely used in making iron and steel, as well as in manufacturing and distributing coke oven gas for various plant uses.

Outstanding performance of R-C equipment is constantly being demonstrated in almost every industry. Typical applications are:

Sugar refining
Scavenging Diesel engines
Neon sign manufacturing
Tunnel ventilation
Playing pneumatic calliopes
Carburetor testing
Coal treating
Operation as air motors

The *dual-ability* of Roots-Connersville to engineer and build suitable equipment accounts for its reputation for long, dependable performance. This experience is at your service for moving air, gas or liquids at moderate pressures, in any volume. Call on us without obligation.

ROOTS-CONNERSVILLE BLOWER CORP.
One of the Dresser Industries
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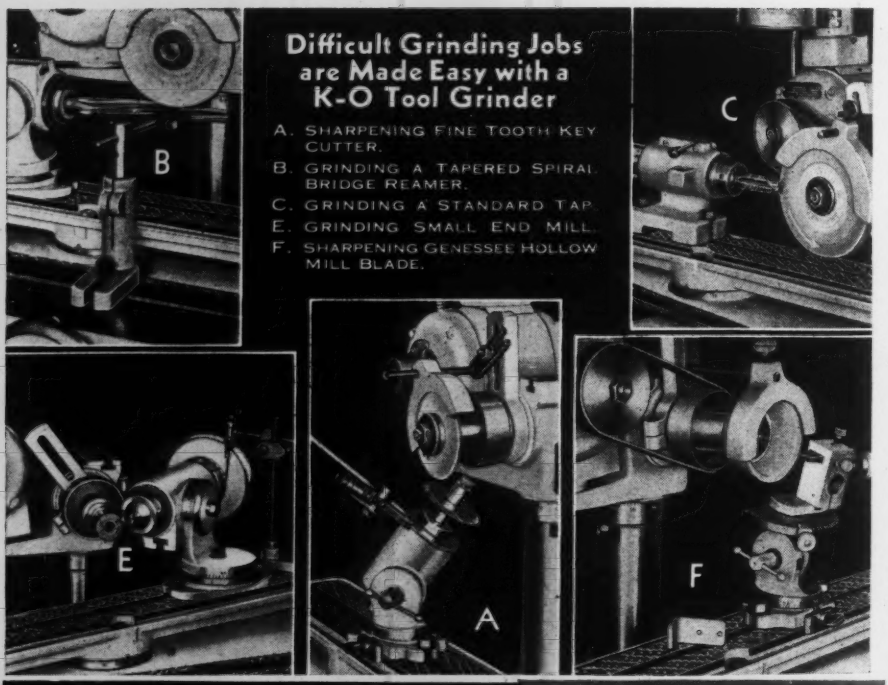
Roots CONNERSVILLE SINCE 1854

ROTARY POSITIVE AND CENTRIFUGAL BLOWERS • EXHAUSTERS • BOOSTERS
LIQUID AND VACUUM PUMPS • METERS • INERT GAS GENERATORS



Knock-Out Engineers have made available more time-tested grinder fixtures than has any other manufacturer. If it can be done—it can be done more easily and economically on a K-O Grinder.

Model B600 Single Speed Universal Tool Grinder.

Write Knock-Out at Aberdeen for booklet No. 33-125.

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K.O. LEE COMPANY

ABERDEEN, SOUTH DAKOTA

Manufacturers of fine tools and equipment for over thirty years

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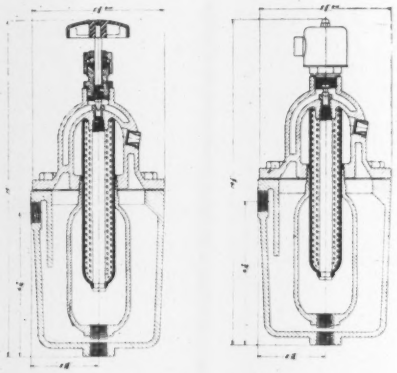
portion of the apparatus is attached to the moving crosshead. The pointer sprocket wheel and the sprocket wheel on the drive unit are connected by an endless weighted chain. With the gear selected for a certain speed the hydraulic valve of the testing machine is opened until the loading head rises to a rate where the dial pointer stands still. This means that the pointer sprocket and the motor driven sprocket below are moving at exactly the same speed. They counteract each other. This adjustment is simply made.

The Southwark Ram Pacer actually is a combination tool since it also can be used as a deflectometer. The dial is divided into two hundred graduations of .001 of an inch each, and if the synchronous motor is not turned on, the dial will indicate the deflection of a specimen under test.

Two New Armstrong Humidifiers

Two new steam-type humidifiers, utilizing a venturi nozzle to discharge steam, are now in production at Armstrong Machine Works, Three Rivers, Mich., manufacturers of steam traps, air traps, refrigeration purgers, and steam-type humidifiers.



One of the models has a solenoid valve to automatically control the discharge of steam, while the other one has a hand-operated valve to meet the need for manually controlled humidification.

The venturi replaces an electric fan and motor used on the older Armstrong models. By virtue of fast steam discharge through the venturi thorough mixing with the air is assured.

One advantage of these new units is simplified maintenance, since there is no motor to oil. Elimination of the motor also reduces the electrical load on the humidistat, which controls relative humidity by making and breaking an electrical circuit.

Magnets—Permanent and Strong

Recent war-important and new peacetime applications of permanent magnets of a high order of strength have made necessary the construction of a powerful magnetizing device. Mr. J. E. Goldman of the Westinghouse Research Laboratories has designed and built a 28,000-watt magnet expected to develop a maximum field of 40,000 gausses between the pole pieces spaced one-half inch apart. It is anticipated that this is one of the most powerful magnets in the country for large gap spacings.

The pole pieces are attracted to each other with a force of 4000 pounds. To resist this two-ton pull, the two pole assemblies are mounted on a large lathe bed, one yoke being hand set and the other motor driven. The equipment is entirely remotely controlled. The coils of the magnet are energized by a separate d-c generator. These coils comprise 6400 turns of #8 square

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copper wire with glass-cloth insulation treated with temperature resistant impregnant. The windings are wound in eight sections, four pairs connected in parallel. At maximum load, the magnet draws 220 amperes at 150 volts.

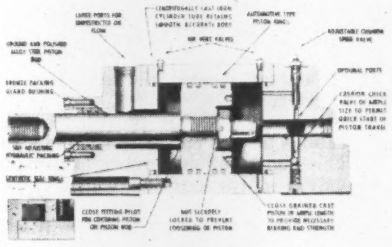
Each coil is cooled with a circulating-oil heat exchanger to dissipate the heat generated in consuming 28 kilowatts.

Duplicating between four and one-half inch pole pieces the force of a large lifting magnet several feet in diameter—such as used in handling scrap iron—the magnetic field is so strong that superpowerful permanent magnets can be made in it. It is expected that this new piece of apparatus will prove valuable in research work involving the study of the effect on the properties of metals caused by variations of intense magnetic fields.

Positioned between the magnet pole pieces is a magnetic field measuring device called a generating flux meter by its developer, J. E. Goldman. A constant-speed motor turns a small coil in the field to be measured. The speed and size of the coil being constant, the voltage generated is a function of the strength of the field in which the coil revolves.

New Complete Line of Logan "Rotocast" Hydraulic Cylinders

Maximum power without leakage and lasting accuracy of bore dimensions result from the centrifugal-cast barrels and other advanced features of the new, improved Logan "Rotocast" Hydraulic Cylinders. A complete line of these cylinders has just been announced by the Logansport Machine Co., Inc., Logansport, Ind., manufacturers of air and hydraulic equipment.



Making efficient use of smooth-operating hydraulic power, "Rotocast" Cylinders are adapted for a wide range of operations involving pushing, clamping, lifting, forcing, holding, pulling, pressing and other power movements in any direction. They will permit improved product efficiency with lower operating costs when incorporated in hydraulic equipment offered on the market. They can also be used advantageously on new or old equipment in manufacturing and processing industries, material handling and many other applications in diversified fields. The smooth, clean lines harmonize with the modern styling of today's industrial equipment.

To fit the greatest number of applications, standard "Rotocast" Hydraulic Cylinders are offered in 7 mounting types, 3 piston rod models and 9 standard bores. They are available with cushioning at one or both ends if desired. Although designed primarily for oil service, "Rotocast" Cylinders may be used for water service if the water is treated; if untreated water must be used, cylinders of special material can be supplied. These cylinders are built for operating pressures to 1500 p.s.i.

A number of advanced features and engineering developments are incorporated in the new Logan "Rotocast" Hydraulic Cylinders. Outstanding among these is the

Continued on Page 42

POWER WITH

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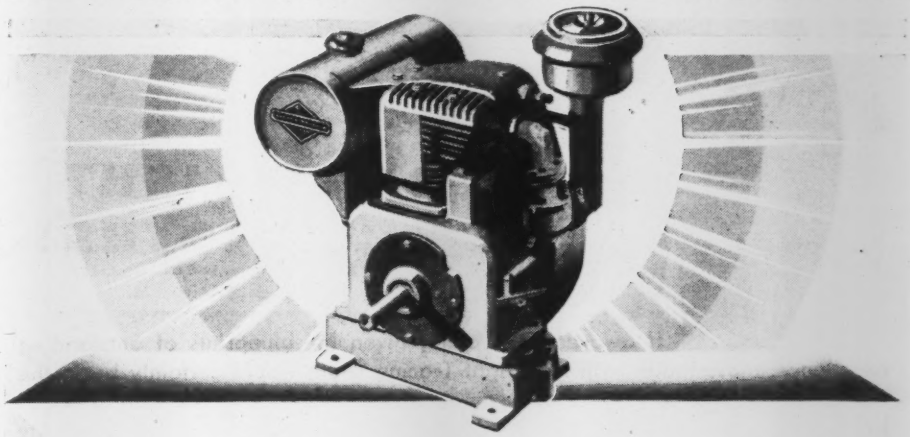
Air-Cooled Engines

YOUR ASSURANCE OF MAXIMUM PERFORMANCE



In a brilliant record of dependable and economical operation — well above 2¼ MILLION Briggs & Stratton 4-cycle gasoline engines have *earned undisputed* recognition as "preferred power" the world over. Current models are the result of skill and experience gained during more than 26 years of *continuous production* of single-cylinder Air-Cooled engines — and constant advancements in design and precision manufacture. These distinctive Briggs & Stratton advantages are your assurance of *maximum performance* — the *right power* — whether you build, sell, or use gasoline-powered appliances, machinery, or industrial equipment.

BRIGGS & STRATTON CORPORATION
Milwaukee 1, Wisconsin, U. S. A.

Air-Cooled Power

4 CYCLE BRIGGS & STRATTON GASOLINE ENGINES

If awards were being given for blueprints of outstanding excellence, those made with Arkwright Tracing Cloth would certainly be in the Blue Ribbon class! Arkwright cloths contain no surface oils to become opaque and brittle with age. Exceptionally high, longer lasting transparency is obtained by Arkwright's exclusive mechanical processing methods.

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unusual dimensional stability of the cylinder bore which results from the improved method of producing the barrel. As indicated by the name "Rotocast", cylinder barrels are centrifugally cast from close-grained grey iron which retains its original dimensional accuracy for the life of the cylinder.

This permits smooth, true bores, honed to a mirror finish, and assures a uniform flow of power with minimum friction and piston leakage. 4 automotive type piston rings further contribute to positive operation with maximum power.

The sturdy end covers are made of close-grained alloy cast iron, and are attached directly to the barrel by heat treated socket-head cap screws. No tie rods are employed. The end covers may be rotated on the barrel so as to place the vent ports at the top, bottom or either side. Alternate pipe tap locations, tapped and plugged, are also provided.

Cover attachment holes are standard on all models. This makes the covers of the various types completely interchangeable, and permits a wide range of combination mountings such as flange mounting at rod end with foot mounting at blind end, etc. Standard mounting types include rabbeted, foot, center-line, clevis, trunnion, flange at blind end, and flange at rod end.

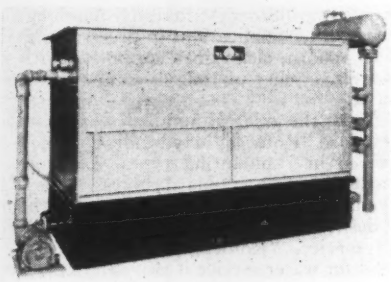
Conventional gaskets have been eliminated in the new "Rotocast" Cylinders. In their place, soft synthetic "O" rings are used to provide a permanently leak-proof seal between the cylinder barrel and end covers. "O" rings maintain a perfect seal even though the applied pressure is increased or decreased, and have a far longer service life than the usual gaskets.

Foot mounting and center-line mounting "Rotocast" Hydraulic cylinders have finished mounting surfaces to facilitate anchoring the cylinders by means of keys. The keys do not lay against the mounting surfaces of the covers.

Small tapped holes are provided at various locations in each end of the cylinder barrel. This construction permits locating air vent valves in the position which permits air to be vented or bled from the highest point, regardless of the mounted position of the cylinder.

New Niagara Industrial Liquid Cooler

Furnishes refrigerated cooling water or any aqueous solution for industrial uses, especially the cooling of water to the lowest possible temperature above freezing for air conditioning or water cooling jackets—or in chemical, photographic and industrial processes—or as used in milk plants, bakeries and other food industries.



The method used is to spray the cooling water over banks of coils in which the refrigerant is expanded. The water falls into a tank and is recirculated independently of the distributing system, thereby gaining the closest control over temperatures and efficiency in heat transfer regardless of intermittent cooling operations or variations

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from maximum to minimum cooling load. By means of newly developed coil arrangement and design, capacity increases of 50% to 100% are gained over the company's previous equipment in comparable sizes. The result is equipment of greater compactness, capacity and rapidity of cooling as well as absolute temperature control. It is possible to produce 33° water constantly without danger of damage from freezing—as the system is open and does not depend for safety on the proper functioning of the back pressure regulating valve. To provide temperatures below freezing, the coolers may be operated with Niagara "No Frost" liquid solution.

The range of capacities in different sizes runs from 4.7 to 137 tons refrigeration. The model rated at 137 tons is 105" long by 88" high by 60" wide. Water deliveries range from 11 to 220 gallons per minute.

The company's experience with this type of equipment has resulted in many features of convenience and ease of maintenance. All parts are accessible for cleaning and experience shows that coils stay clean indefinitely regardless of water source if the tank is cleaned weekly. Tank is ample in size. Special provision is made for the application of insulating materials. The equipment is manufactured by the Niagara Blower Co., 6 E. 45th St., New York 17, N. Y.

New Developments in Quimby Screw Pumps

Quimby Pump Co., a division of H. K. Porter Company, Inc., announces new developments in its balanced quadruplicate screw pump.

Improvements are demonstrated by the new external bearing pump designed with bracket type anti-friction thrust and line bearings. Separate pedestals with the three-point alignment problem and spacing washers are eliminated, providing free expansion of shafts for wide changes in temperatures. Precision pre-loaded anti-friction bearings permit close running clearance between the body bores and the screws.

This new construction can be provided on all existing pumps without disturbing present pipe connections or location of the motor.

The Quimby screw pump, the first positive displacement pump developed in America, has been progressively refined since its introduction in 1894. Designed for pumping various viscous liquids such as Bunker C fuel oil, tar, rayon dope, molasses, soap liquids, etc., it is also used in handling thin liquids, such as water, alcohol, and commercial solvents of various types.

New Liquidometer Hydraulic Valve Stem Position Indicator, Developed For Navy, Now Available For Industrial Applications

A new remote-reading hydraulic Valve Stem Position Indicator, developed by The Liquidometer Corp. for the Navy to aid in controlling and isolating below-deck fires aboard carriers and other large warcraft, is now available for many industrial applications.

These indicators show the open or shut position of valves which control the flow of fuel and other liquids. Development of the indicator was made under the direction of J. J. Cosgrove, Marine Division, The Liquidometer Corp., Long Island City, in conjunction with Jenkins Bros., Bridgeport, Conn., who developed the transmitter and hydraulically-actuated mechanism for opening or closing the valve.

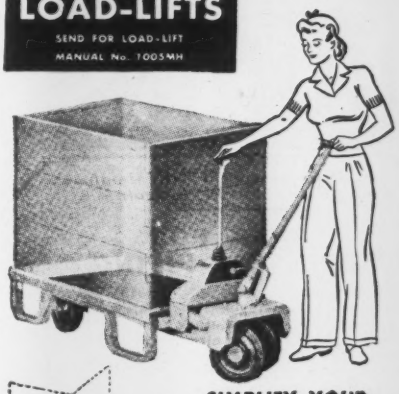
This Valve Stem Position Indicator which has proved itself in ruggedness and de-

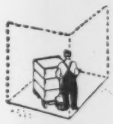
Continued on Page 44

STANDARDIZED MATERIALS HANDLING EQUIPMENT

LOAD-LIFTS

SEND FOR LOAD-LIFT MANUAL No. 1005MH





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The use of the Load-Lift system will greatly increase your plant efficiency for the smallest capital investment of any adequate materials handling system. Saves double handling — utilizes space advantageously — reduces fatigue — eliminates damage from elements.

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98 GARVEY ST., EVERETT 49, MASS.

Polaroid* ... Photoelastic Polariscope for Stress Determination

For either qualitative or quantitative photo-elastic analysis, perfection in the projection lens system is of major importance.

In our new model polariscope of 4¼" clear aperture, the parallel beam is collected by a rear element and condensed through a three component lens of the Cooke system. In the new larger unit (8¼" aperture) a four component lens of the Omnar system is used. *The image is sharp throughout the field, free of aberration, astigmatism, and distortion.*

Literature of new model polariscope now available

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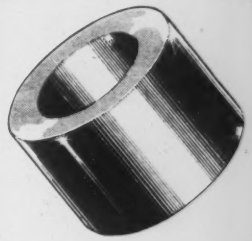

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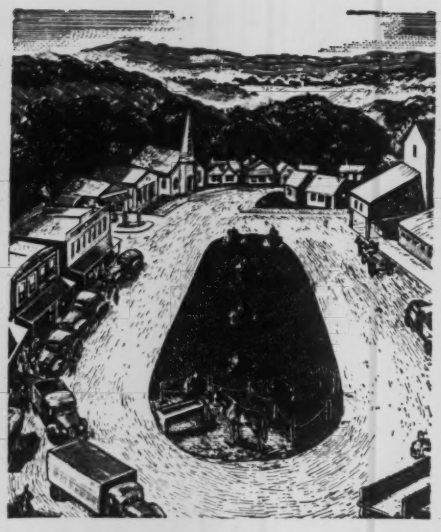

"Centerville" Is Putting In a LAYNE WATER SYSTEM

"Centervilles" throughout the nation are rapidly graduating from town-pump villages. Their growth and stability as cities of lovely homes, fine business houses and progressive citizens has called for the installation of a modern water system. Officials of "Centerville" are beginning right—taking no chances on water supply failure—expensive operation, or short life of wells and pumps. They are putting in a Layne Well Water System. Investigation has shown "Centerville's" officials that a Layne Well Water System is easily within their means and is a sound and profitable investment.

These same kind of Layne Well Water Systems and Layne Vertical Turbine Pumps are serving the nation's largest cities—the greatest industries, biggest railroads, and the most extensive irrigation projects. Layne water producing equipment enjoys the reputation of being the world's best—and that reputation is constantly growing stronger and stronger.

Layne offers fine and always dependable Well Water System counsel with no obligation. For further facts, catalogs, etc., address Layne & Bowler, Inc., General Offices, Memphis 8, Tenn.

HIGHEST EFFICIENCY

Layne Vertical Turbine Pumps are now available in sizes to produce from 40 to 16,000 gallons of water per minute. Their high efficiency saves hundreds of dollars on power cost per year.

AFFILIATED COMPANIES: Layne-Arkansas Co., Stuttgart, Ark. ★ Layne-Atlantic Co., Norfolk, Va. ★ Layne-Central Co., Memphis, Tenn. ★ Layne-Northern Co., Mishawaka, Ind. ★ Layne-Louisiana Co., Lake Charles, La. ★ Louisiana Well Co., Monroe, La. ★ Layne-New York Co., New York City ★ Layne-Northwest Co., Milwaukee, Wis. ★ Layne-Ohio Co., Columbus, Ohio ★ Layne-Texas Co., Houston, Texas ★ Layne-Western Co., Kansas City, Mo. ★ Layne-Western Co. of Minnesota, Minneapolis, Minn. ★ International Water Supply Ltd., London, Ontario, Canada ★ Layne-Hispano Americana, S. A., Mexico, D. F.

LAYNE

WELL WATER SYSTEMS
VERTICAL TURBINE PUMPS

BOOKS

20% Discount to A.S.M.E. Members on publications in this column.

CODE FOR PRESSURE PIPING

A dependable source of information on design, fabrication, and installation of piping used in steam generating and industrial plants; for conveying air; fuel, illuminating and non-corrosive gases; oil; refrigerant brine; and steam and hot water.

Published 1942 (B31.1) $2.00

MANUAL ON CUTTING OF METALS

A 320-page book for shop men, presenting tested data in tabular form from which speeds and feeds for metals in common use can be set for various depths of cuts. Time and horsepower necessary for a cut under stated conditions are also shown, as well as examples in the use of the data.

Published 1939 $5.00

SAFETY CODE FOR CRANES

A standard guide for the construction, installation, inspection, maintenance, and operation of cranes, and derricks driven by steam engines, electric motors, or internal combustion engines to their runways, to simple hoists, to overhead electric hoists and their runways, to overhead air hoists, and to hand-powered derricks.

Published 1943 (B30.2) $1.50

SAFETY CODE FOR ELEVATORS

Designed to insure safety in the construction, inspection, maintenance, and operation of all types of elevators, dumbwaiters, and escalators. Detailed recommendations are given for hoistways and enclosures, guides, buffers, counterweights, car construction and safeties, cable and signal systems, speed control, etc.; also for qualification and training of operators.

1937 Publication with 1942 Supplement (A17.1) $1.25

ELEVATOR INSPECTORS' MANUAL

Shows how to make a thorough and satisfactory inspection of all equipment involved from brake action, switches, stopping devices, speed, counterweight safeties, to control and operating equipment, car capacity, emergency exits and release, lighting, hoistway, elevator ropes, and rope sockets.

Published 1937 (A17.2) 75¢

THE AMERICAN SOCIETY OF MECHANICAL ENGINEERS
Publication Sales Dept.
29 West 39th St., New York 18, N.Y.

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pendability aboard the fighting ships of the Navy will find many industrial applications wherever petroleum fuels, chemicals or other valuable, dangerous or inflammable liquids are used.

Valve Stem position is transmitted to the indicator dial through the Liquidometer temperature-compensated dual hydraulic transmission system, which requires no outside source of power. Thus it will continue to function in case of temporary failure in the plant's power supply. With this system, the indicator dial may be located at the transmitter or any reasonable distance from the valve.

When used in industrial plants, all the indicators can be located on a single panel with the transmitters adjacent, thus making it possible for one operator to see and control the position of every valve.

New Ohmite Series 84 Riteohm Precision Resistors

New "Series 84" in Types 844B, 844A, and 842A, is the latest addition to the Ohmite Riteohm Precision Resistor line which includes the Riteohm Series 71, 81, 82, 83 and 90. This new series was developed to meet the demand for a precision resistor capable of being mounted by means of a through-bolt and equipped with a radial lug at each end.

The Riteohm 84 is pie-wound to 1% accuracy and is available in 3 sizes—$^{9}/_{16}$" diameter by $^{9}/_{16}$" long, $^{9}/_{16}$" diameter by $^{7}/_{8}$" long, and $^{3}/_{4}$" diameter by $1^{3}/_{16}$" long. The smallest is a 2 pie while the other two are 4 pie units. The minimum resistance is 1.0 ohm for the 2 pie unit and small 4 pie unit, and .10 ohm for the large 4 pie unit. The maximum resistance is 200,000 ohms for the 2 pie, 400,000 ohms for the small 4 pie, and 1.5 megohms for the large 4 pie unit.

A few common uses for such a resistor are for volt meter multipliers, laboratory equipment, radio and electrical test sets, attenuation pads and in electronic equipment requiring extremely accurate resistance components.

Specially enameled alloy resistance wire is non-inductively pie-wound on a non-hygro-

VICTORY LOAN

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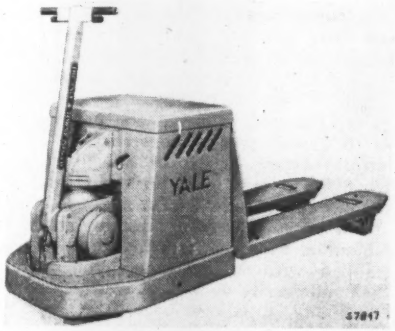
scopic ceramic bobbin which has a hole through the center for a No. 6 screw. Lug type terminals on the Riteohm 84 are firmly fastened to the bobbin. After being wound, the unit is vacuum impregnated with a special varnish which provides additional insulation and thoroughly protects the winding against humidity. The resistor can be supplied with a varnish coating containing a fungicidal agent, thus making the unit particularly suited for use in the tropics.

For further information, write for Bulletin No. 126 to the Ohmite Manufacturing Co., 4835 Flournoy St., Chicago 44, Ill.

Yale Adds Electric Lift Truck to Line

Newly added to the Yale line of material handling machinery is the Worksaver Electric Truck. With power for lifting and power for travel, the Worksaver relieves its operator of all physical strain. Compact and easily controlled, it can be maneuvered in congested areas, along narrow passages, and around sharp corners without waste of time or effort.



The Worksaver actually reduces material handling to little more than a strolling and steering operation. A man or woman operator can pick up and "walk off" with loads up to 3 tons merely by using finger-tip pressure on dual cam controls located immediately beneath the hand bar-grip. These controls are designed so that when finger pressure is released, they return to neutral—cut off the power. Two forward and two reverse speeds are provided.

The elevating unit on the truck consists of a high-torque electric motor which operates a Yale-designed high-pressure hydraulic gear pump, which, in turn, activates a ram. Lifting and lowering is controlled by a convenient switch placed on the front of the battery compartment. The hydraulic ram operates in a honed cylinder, to provide long, efficient operation; and the electric control and valve mechanism are interlocked, to eliminate overtravel of the lift.

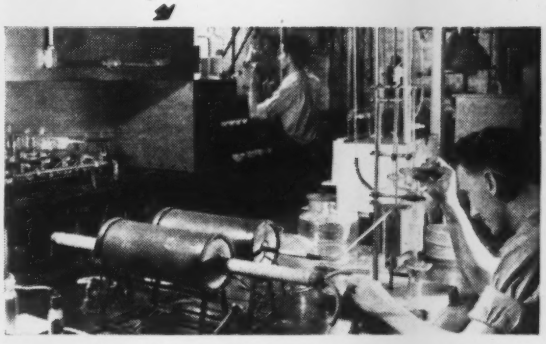
When a load is deposited, a special type of hydraulic release check cushions the descent, thus protecting load, floor, and operator.

The drive motor, located at the base of the steering handle, is a high-torque, ball bearing type. A drive pinion, mounted on its armature shaft, operates through a double-reduction spur-geared unit, running in lubricant, to drive a ten-inch diameter, rubber-tired front wheel. The drive unit is mounted on a 16"-diameter ball bearing turntable, immediately above the front wheel. Steering merely involves turning the turntable with the steering handle. The design of the front assembly is such that the truck can be turned in its own length.

Power for both the elevating and drive motors is obtained from a lead or alkaline battery housed in a compartment which is an integral part of the truck chassis. This

Continued on Page 46

From selection of Raw Materials ...to Final Assembly



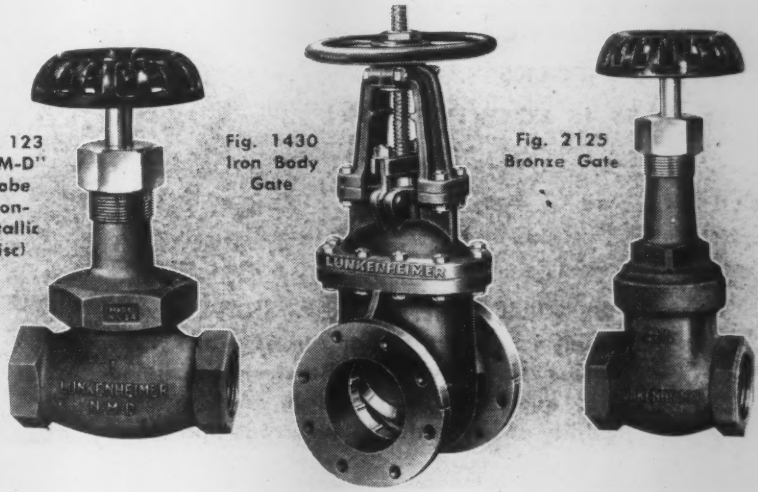
RELIABLE SERVICE, LONG LIFE, LOW MAINTENANCE COST ARE BUILT INTO

LUNKENHEIMER VALVES

Selection of the finest raw materials . . . careful testing of each lot of molten metal before it is drawn from furnace or cupola . . . perfect castings made in modern foundries . . . accurate grinding and finishing by skilled mechanics operating the most advanced modern machinery . . . final assembly and checking to rigid standards . . . *These* are the factors that build *quality* into every Lunkenheimer Valve — quality which assures that outstanding performance, longer service life, and minimum upkeep familiar to maintenance men everywhere.

The present demand for Lunkenheimer Valves continues at peak levels. But we've geared our facilities to meet it and maintain, through established and authorized Lunkenheimer Distributors, the quick and efficient service which American industry has come to expect and rely upon.

The Lunkenheimer Co., Cincinnati 14, Ohio, U. S. A. (Offices: New York 13, Chicago 6, Boston 10, Philadelphia 7. Export Department: 318-322 Hudson Street, New York 13, N. Y.)

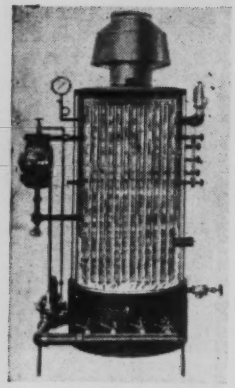


Call On Your LUNKENHEIMER DISTRIBUTOR!

You'll find him fully equipped and ready at all times to assist you in solving problems of valve maintenance and operation. The functions he performs are highly important in the Lunkenheimer set-up, designed to give you better, more efficient, more reliable valve service. Lunkenheimer Distributors are located in principal industrial centers. There's one near you with complete service facilities.

BRONZE, IRON, STEEL, AND CORROSION RESISTANT ALLOY VALVES— AIR DEVICES, LUBRICATORS, AIRCRAFT FITTINGS

Order those boilers . . . ahead of time



Steam boiler requirements should be anticipated well in advance of the time the boiler is actually scheduled for use.

When specifying a steam boiler, engineers should consider the widely used KANE built in sizes up to 30 H. P. to A.S.M.E. standards.

Gas-fired, automatic, the KANE boiler is selected for precise temperature control, cleanliness, minimum space requirements and long, trouble-free, service life.

MEARS-KANE-OFELDT INC
Manufacturers of Automatic Steam Boilers for over a third of a century.
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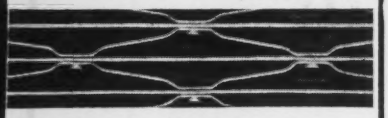

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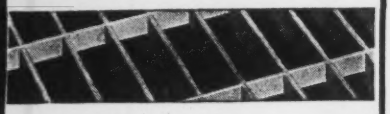

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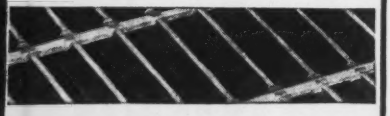

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MY BOSS IS LOOKING FOR!

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SPECIALISTS in SHAPES laminated from resins and fabrics (glass, synthetic or cotton) to exacting needs of America's leading industrial engineers. Tell us your shape requirements. We probably can submit samples similar to your needs. Write to Andover Kent, New Brunswick, N. J. — TODAY!

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compartment has a hinged cover and removable sides for convenient charging and change of batteries.

The main frame of the Worksaver is of heavy formed bar and plate steel, arc-welded into a strong and durable unit chassis. A continuous channel bumper reinforces the entire power unit assembly and battery compartment, and provides great travel stability.

The load elevating linkage is of patented Yale design, which affords maximum grade clearance.

The Worksaver is available in two types: (1) platform, (2) pallet. The former is designed to handle single unit loads, consisting of a crate, bale, etc., or multi-unit loads on skids or in skid bins up to 6,000 lbs; the latter to handle single or multi-unit loads which are "palletized," up to 4,000 lbs.

The platform of the platform type Worksaver is of heavy formed steel plate, with apron on sides and at front end to give added strength and protection. Platforms are available in seven different lengths, ranging from 36″ to 72″, in 6″ steps. Maximum overall length of this truck thus varies from $70\frac{1}{4}$″ to $106\frac{1}{4}$″. Overall width is 31″, and overall height (at the battery compartment) is $27\frac{3}{4}$″. Rear wheels come in 6″, 7″, and 10″ diameters.

The U-shaped frame of the pallet model has the same sturdy construction as the platform type. The forks are $9\frac{1}{4}$″ wide, with $8\frac{1}{2}$″ in between. Fork lengths range from 36″ to 60″, in 6″ steps.

Both single and double-faced pallets can be handled with this truck, the forks being equipped with Yale-designed roller trains which slide easily over the lower face boards of double-faced pallets.

Important safety features are found in the mechanism of the Worksaver. When the cam controls on the steering handle are at neutral, the brake is "on." When the steering handle is in vertical or horizontal position, the brake is automatically applied and the power is cut off. This arrangement not only gives the operator complete control of the truck on ramps, but, in the event the handle is dropped by accident, the truck is halted immediately.

The Worksaver is illustrated and described in a new catalog which will be sent on request. Write The Yale & Towne Manufacturing Co., 4530 Tacony Street, Philadelphia 24, Pa.

Simple Setup for Small-Lot Flame-Hardening of Valve Plugs

The useful life of plug valves used in oil refinery equipment depends largely upon their resistance to wear and to thermal shock. A manufacturer supplying valves for such tough jobs has found that the oxy-acetylene flame-hardening process is the best method of obtaining the desired physical surface properties in the plugs used in these valves.

A simple hand-operated jig has been set up for flame-hardening plugs used in valves ranging from 1-in. to 16-in. pipe size. The plugs are made of type G. A. Meehanite, which has a basic hardness of 250 on the Brinell scale. Using the progressive flame-hardening method followed by a water quench, a $\frac{1}{16}$-in. case with a Brinell hardness of 400 is produced at the rate of approximately 12 in. per minute. Operating conditions such as flame intensity, speed of travel of the heating flame, and type of steel being treated can be varied to produce special hardness and depth.

The use of a mechanized installation was considered but because of the small production capacity of the plant it was felt that the use of such a mass production flame-harden-

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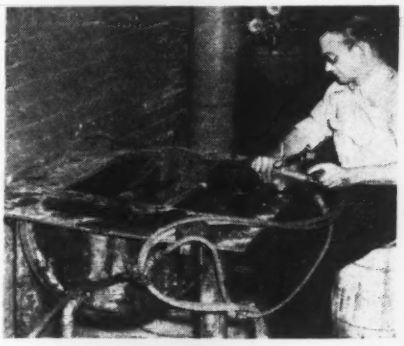
ing tool would not be justified in this case. The various sizes of plugs, made in small lot orders, can be very effectively heat-treated with the versatile, simple hand-operated setup.



In using the progressive flame-hardening method the operator moves the heating blowpipe laterally along the surface of the plug at a uniform rate of speed. Immediately behind this flame is a stream or spray of water which progressively quenches the heated surface. The direction of movement is guided by a clamped bar which can be adjusted to keep the tip of the blowpipe at a constant distance from the surface of the work. After each pass the work is rotated until the hardened portion is submerged in the protective water bath, and a new segment of its surface is hardened in the same manner.

The entire surface of the plug with the exception of the sharp machined corners of the passageway is hardened and then finished by lapping. Since flame-hardening is accompanied by a minimum of distortion, the plugs can be machined before hardening—a procedure that would have been impossible with the previous method of hardening. This has resulted in substantial savings in machining costs. The above illustration shows the simple equipment used for flame-hardening these plugs.

Electromet Announces Special Low-Carbon Ferromanganese

A new special low-carbon ferromanganese, available at the same price as the regular grade, has just been announced by Electro Metallurgical Sales Corp., a Unit of Union Carbide and Carbon Corp. This special grade is produced in the maximum 0.10% carbon grade; the following is a typical analysis:

Manganese	90.00% min.
Phosphorus	0.06%
Carbon	0.06%

The high ratio of manganese to undesirable elements in this special low-carbon ferromanganese makes it particularly useful for adding manganese to stainless steel and other quality steels where high purity is essential.

Westinghouse Announces Grease for Ball and Roller Bearing Motors

For dependable lubrication from 13° F to 176° F for all speeds up to 3600 rpm and for horizontal or vertical operation, an improved grease for ball and roller bearing motors is announced by the Westinghouse Electric Corp.

Available in a new eight ounce nasal type tube, the grease is stable, highly resistant to oxidation, and will remain in a bearing for an indefinite period without drying out, caking or separating. The new tube is designed for easy and economical use. It has a large opening in the long nasal spout which fits into a one-eighth inch pipe coupling,

Continued on Page 48

50 YEARS AGO

the first automobile race

On Thanksgiving Day, 1895, the first automobile race ever run in America started from the building now housing the Museum of Science and Industry in Chicago. This event started the great race of industrial progress in America—a progress which has been paced by the dynamic automotive industry.

To commemorate this Golden Jubilee of the automobile, the Museum of Science and Industry recreated this race over the same course, with the same type cars on Thanksgiving Day, 1945.

Industrial Progress
MAKES AMERICA GREAT

AN important contributing factor in the production of more and better things for better living has been the development in the use of cutting fluids and specialized lubricants. Thirty years before the first automoble race, the D. A. Stuart Oil Company began furnishing industrial oils to American industry. And ever since, this company has devoted itself exclusively to the job of making better cutting fluids and helping industry use them to greatest advantage. This long, valuable background, as well as the latest experience resulting from Stuart's close integration in the war production program, is at your service. In your plans for future progress, the Stuart organization would like to help you use cutting fluids to the best advantage. Invite an engineer to call on you. Write D. A. Stuart Oil Company, Limited, 2741 South Troy Street, Chicago 23, Illinois.

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ESTABLISHED 1865
Stocks in Principal Metal-Working Centers

and a key with which to wind and exert pressure from the bottom of the tube.

Further information on the grease may be secured from Box 868, Westinghouse Electric Corp., 306 Fourth Avenue, Pittsburgh 30, Pa.

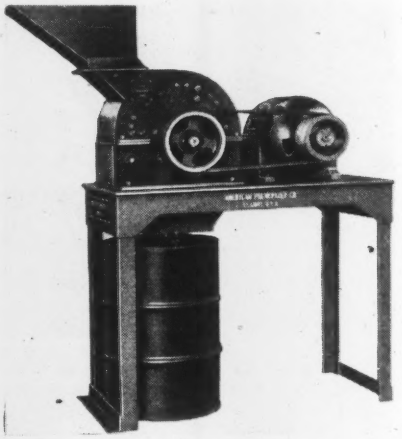
Rotary Knife Chopper ReducesThermoplastics

The development of the American "KC" Rotary Knife Chopper makes possible the uniform granulation of plastic scrap to homogenous granules for uniform mold flow. The profitable reduction of thermoplastics scrap with the American "KC" Rotary Knife Chopper is a once-through, fast, single operation.

The ability of this machine to reduce cellulosics, styrenes, acrylics, polyethyls, butyrates and vinyls, yet maintain control of granule size, even if the product softens at temperatures as low as 40 to 50 degrees C, makes a place for this equipment wherever the molder or fabricator desires reclamation of scrap.

The nature, size and shape of the thermoplastic fed to the American "KC," whether sprues, gates, warm-up shots or rejects offers no production problem.

Uniform granulation is achieved by the clean, shearing process of three adjustable, hardened tool steel, cutter blades affixed to a heavy balanced rotor as they revolve past stationary knives in the reduction chamber. Fines are held to an inconsequential minimum by the shearing action, and oversize is prevented by the sizing of the screen.



The American "KC" with a capacity of 200 to 400 lbs. per hr. occupies a floor space of only 36″ × 72″.

The rugged, welded steel plate frame and housing, alloy steel shaft, tool steel cutter bars, dust-tight pillow blocks and anti-friction bearings assure smooth, quiet operation and long life under hard and constant usage. Metal inserts, when inadvertently fed with material, cause no serious damage to the machine.

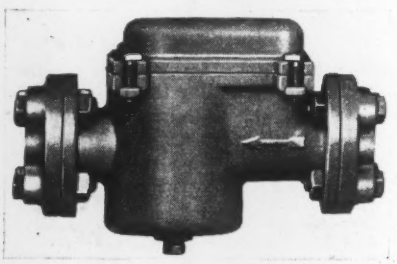
Contamination of materials is prevented by the smooth crushing chamber which is easily and quickly cleaned.

A hopper feed safety door is consistent with the non-hazardous operation which enables the machine to be operated by ordinary workers at low labor cost. The safety door prevents operator's contact with the cutters and protects the operator by deflecting flying pieces while the material is being fed.

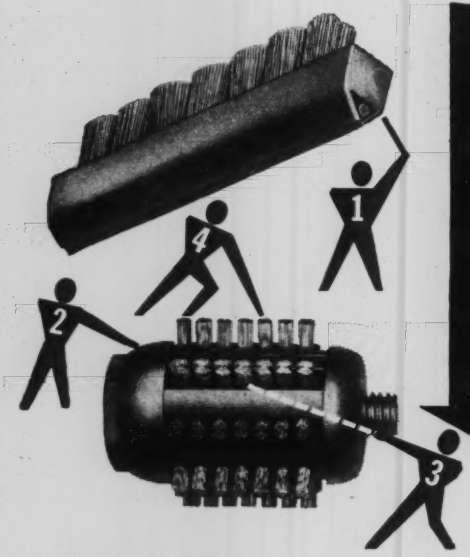
The American "KC" Rotary Knife Chopper is designed and manufactured by the American Pulverizer Co., 1541 Macklind Avenue, St. Louis 10, Missouri, who manufacture reduction equipment exclusively, and are the originators and manufacturers of ring crushers and pulverizers famous all over the world.

New Blackmer "Low-Swing" Strainer

Several improvements over existing equipment are claimed for a new Blackmer strainer recently announced by J. B. Trotman, General Sales Manager of the Blackmer Pump Co., Grand Rapids, Mich.



Developed by Blackmer engineers as a wartime protective and conservation measure for critical pumping equipment, the new Low-Swing strainer has been added to the company's line of Ezy-Kleen strainers and is now available for reasonably prompt delivery.



4 reasons why WILSON EXPANDING BRUSHES mean dollars in your pocket

No tube cleaner is better than its "working end" — that is why an expanding brush can mean money in your pocket. Wilson — aware of this fact — has developed a BETTER expanding brush. Its exclusive features guarantee you a BETTER tube cleaning job—and lower maintenance costs. The photographs above show these features:

1 Exclusive patented one piece cartridge design; substantial channel walls prevent tufts from "punching through" while solid, long-wearing side walls together with spring-tempered tinned steel brush wires, assure longest brush life.

2 Replaceable retainer cap on front end takes wear at this point. When cap wears out, you can replace it at low cost and your brush is as good as new.

3 Air driven brushes are allowed to expand centrifugally while those operating on electrically driven equipment are spring expanded. This "tailoring to fit the job" assures faster, more thorough tube cleaning jobs.

4 Wilson Expanding Brushes for tubes from 1″ to 2¾″ have more brush cartridges than any other brush on the market. This means more cleaning surface, better cleaning and less brush wear.

All these features add up to save you money where Wilson Tube Cleaner Brushes can be used. Add a supply of better WILSON EXPANDING BRUSHES and refills to your tube cleaning kit today. Immediate delivery from stock.

wilson

TW-700

THOMAS C. WILSON Inc.
21-11 44th AVENUE, LONG ISLAND CITY 1, NEW YORK

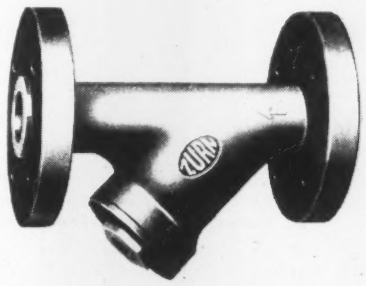
• Keep Informed

The following advantages appear from field reports on the new strainer: 1. Use of perforated metal, steel or bronze, instead of wire screen for the strainer basket makes the basket less liable to damage in cleaning and gives it longer life. 2. Slotted lugs of the top plate line up with the lugs of the strainer body to receive the four holding bolts. This permits quicker removal of basket for cleaning. 3. Compact design permits mounting in small space or in lines along walls. 4. Strainer is designed for flange mounting. Companion flanges are included as a part of the unit.

Present production is limited to a capacity of 100 GPM with 2-in., $2^1/_2$-in., and 3-in., intake and discharge sizes. Maximum operating temperature is 600°F. Maximum pressure is 75 psi. Larger and smaller sizes will eventually be added to the line.

Zurn "Y" Strainer

A "Y" Strainer has been designed with a snug fitting strainer sleeve unit to assure trouble free operation. This strainer sleeve is removable but it is so designed that it cannot get out of place or vibrate when in use. This enables the unit to be installed in almost any position on a pipeline. When service conditions require it, the strainer basket is magnetized for intercepting metal particles that are extremely ruinous to valve seats and vital parts of operating pipeline equipment.



All units are hydrostatically tested according to the service pressures under which they will be required to operate. They are available with or without a cleanout plug, or can be furnished with a threaded blow-off connection.

This "Y" Strainer is manufactured in cast bronze, steel, semi-steel or cast iron, depending upon the conditions to which it is subjected. A wide range of sizes is available for flanged, welded or threaded connections. "Y" Strainers are one of a line of strainers manufactured by The J. A. Zurn Manufacturing Co., Erie, Pa., including duplex, vertical, and horizontal types; 90° and 180° pressure and suction types.

• BUSINESS CHANGES

Charles H. Morse III Elected Vice President

Charles H. Morse III has been elected vice president of Fairbanks, Morse & Co., according to an announcement by Col. Robert H. Morse, president.

Mr. Morse will be in charge of research patents, traffic, the company's western pump division, and the Inland Utilities Co., Fairbanks-Morse subsidiary with properties in 41 cities and towns in Colorado, Kansas and New Mexico, Col. Morse said. His headquarters will be in Chicago.

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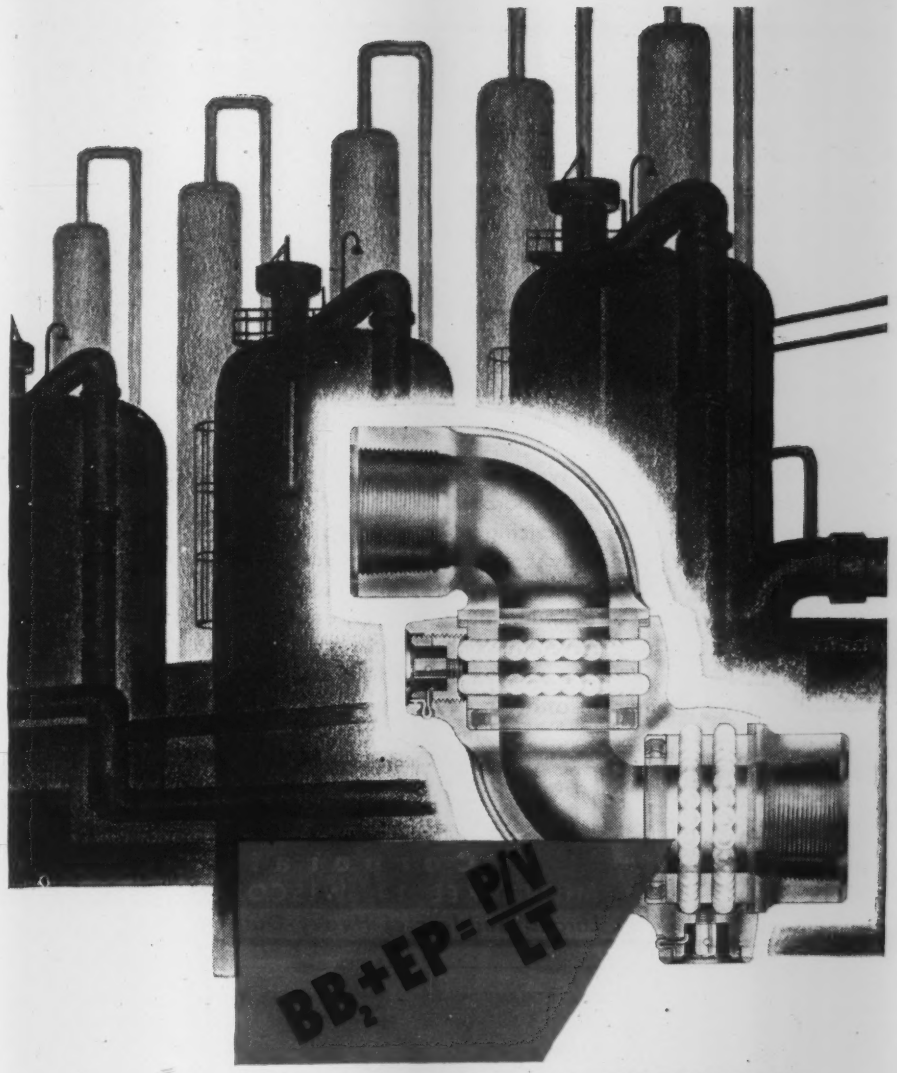


THE CHIKSAN FORMULA

for perfect flexibility meets every demand of industry

CHIKSAN **BALL-BEARING** Swivels got their start and built their reputation for perfect flexibility in the Petroleum Industry. As this Industry became more and more important as a vital source of materials for the manufacture of synthetic products, Chiksan Swivels have proved their adaptability to every need . . . wherever flexibility is required . . . on lines handling steams, acids, alkalies, chemical compounds, gas, gasoline, etc. Many new applications have been developed to speed up production for war and for peace. There are over 500 different Types, Styles and Sizes of Chiksan Swivels. Tell us your requirements and we'll be glad to suggest those best suited to your specific needs.

REPRESENTATIVES IN PRINCIPAL CITIES

BB_2 = Double Rows of Ball Bearings
EP = Effective Packing Element
P/V = Pressure or Vacuum
LT = Low Torque under all conditions

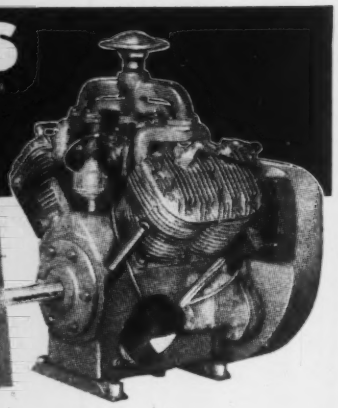
ARMY E NAVY

CHIKSAN TRADE MARK REG

BALL BEARING SWIVEL JOINTS FOR ALL PURPOSES

CHIKSAN COMPANY
BREA, CALIFORNIA

CYLINDERS
are separate from
CRANKCASE



ON ALL
WISCONSIN
4-Cylinder V-Type
Air-Cooled ENGINES

The cylinders on all V-type Wisconsin Air-Cooled Engines are cast in pairs, separate from the crankcase, for quick, economical servicing when required. In case a cylinder is accidentally scored beyond the possibility of reboring, it is only necessary to replace a relatively inexpensive pair of cylinders instead of an entire engine block. The picture shows the Model VE-4 Wisconsin Engine, with protective shrouding removed, illustrating method of attaching cylinders.

Most H.P. per pound

WISCONSIN MOTOR
Corporation
MILWAUKEE 14, WISCONSIN, U. S. A.
World's Largest Builders of Heavy-Duty Air-Cooled Engines

HAERING GLUCOSATES
control
CORROSION, SCALE & ALGAE
in Industrial Plants

WE READ WATER
WRITE FOR THE LATEST "H-O-H LIGHTHOUSE"

D. W. HAERING & CO., Inc.
GENERAL OFFICES:
205 West Wacker Drive, Chicago 6, Ill.

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Immediately after receiving his discharge following two years of service in World War I Mr. Morse entered the company's Three Rivers, Mich., plant as a factory worker. Then followed intensive training in various departments of the company that ranged from factory man up to his present post.

He remained in the Three Rivers plant seven years learning production while working as a screw machine operator, moulder, on the testing floor, and in the engineering department. Then he worked in the firm's electric motors plant, later in the St. Paul sales department, worked in the scales factory at St. Johnsbury, Vt., was promoted to manager of the Memphis sub-branch, and then went to the Diesel engine department in Kansas City.

In 1935 Mr. Morse was elected president of the Inland Utilities Co. Since then he also served for a brief period as assistant general manager of the company's Beloit Works.

He is a son of Col. Robert H. Morse, and a brother of Robert H. Morse, Jr., vice president and general sales manager. His duties will enable him to play an active part in the production of such Fairbanks, Morse & Co. items as Diesel engines, pumps, motors, scales, Diesel locomotives, and other equipment.

AE Appoints Stoker Agent

American Engineering Co., Philadelphia, announces the appointment of R. F. Van Alstyne, 306 Fairmont Street, Davenport, Iowa, as their representative for the sale of Taylor and Perfect Spread Stokers.

His territory includes Des Moines and the Eastern half of Iowa, as well as the Tri-cities.

Mr. Van Alstyne was associated for a number of years with the Whiting Corp. and more recently, the Midland Refractories Corp.

Cochrane Corporation Acquired by Group of Employees

Cochrane Corp. of Philadelphia, manufacturers since 1863 of steam power plant and industrial equipment has been acquired by a group of men long associated with the company in the engineering and sales divisions. The new corporation will be managed and operated by its owners. T. E. McBride was elected president and the following men named as vice-presidents: C. E. Joos, Apparatus Division, V. A. Rohlin, Works Manager, A. E. Kittredge, Chief Engineer, and E. S. Daugherty, Heater Division. The Board of Directors includes H. E. Sibson, for many years the company's General Sales Manager and W. V. Sauter of Philadelphia. There will be no change in the widely-known Cochrane line or sales policies, nor in the nation-wide sales representation of the Company. An aggressive program of development and research is planned to maintain the company's leading position in its field.

Fobian Elected President of Oilgear Co.

George H. Fobian, formerly vice president and director, has been elected president of The Oilgear Co., Milwaukee, Wis., to succeed the late Harry M. Swigart.

R. M. Hatfield Becomes Assistant General Sales Manager of Combustion Engineering

Robert M. Hatfield has resigned as Deputy Vice Chairman of the War Production Board to become Assistant General Sales Manager of Combustion Engineering Co.

A mechanical engineering graduate of Purdue University, Class of 1932, Mr. Hatfield came with Combustion Engineering Co. in 1934 as a student engineer, subsequently

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serving in the Service and Erection Department, the Proposition Department and then as sales engineer in the Cleveland Office. In 1942 he went to Washington as chief of the Boiler Section of the Power Branch, WPB under J. E. Krug and later became Director of the Production Scheduling Division.

He resigned from WPB in May 1944 to accept a commission in the Navy, and in November of that year was assigned back to WPB to take charge of the Navy repair parts program. Last April he was placed on inactive status by the Navy to become Deputy Vice Chairman for Production of WPB which position he held until the War Production Board was abolished on November 2, 1945.

Mr. Hatfield is a member of the A.S.M.E. and a registered Professional Engineer in the State of Ohio.

Aircraft Screw Products Appoints New England Representative

The Aircraft Screw Products Co., Inc., of Long Island City, N. Y., has appointed Donald McClain of Manchester, Conn., as its engineering representative in the New England area.

Mr. McClain had been with Pratt & Whitney's Service Department since 1941, working as a liaison man with the Army and Navy Air Forces and commercial airline operators.

Waldes Kohinoor, Inc. Honors Old Employees

At recent ceremonies held at their plant in Long Island City, the management of Waldes Kohinoor, Inc., honored 65 employees who have been in the company's employ for periods ranging from 10 through 24 years.

Each of the men and women being honored were presented with a $100 U. S. Savings Bond, and were congratulated personally by Sigmund Waldes, President.

In a short talk, Mrs. Hermine Axthelm, Vice President, expressed the appreciation of the company for the long and loyal services of these employees, mentioning particularly the important contributions they had made in the recent years when the plant was occupied with 100% production of war material.

M. M. Miller, Treasurer, a veteran of 23 years employment, made a short speech of acceptance on behalf of his fellow employees.

Those employees who have been with the company for more than 25 years were honored previously. Both ceremonies mark a further step in Waldes' policy to recognize and award long service.

Wert Appointed Southwest General Manager by Kennedy-Van Saun

The Kennedy-Van Saun Mfg. & Eng. Corp., 2 Park Avenue, New York 16, N. Y., takes great pleasure in announcing the appointment of Edwin A. Wert on September 1, 1945, as General Manager of the Southwest Region, consisting of Arizona, California, Colorado, Utah, and New Mexico with offices located in the Ninth & Hill Building—315 West Ninth Street, Los Angeles, California.

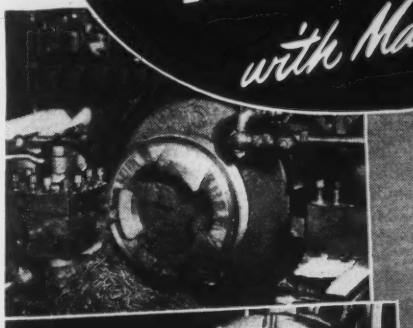
Mr. Wert is a Consultant with the Detroit Edison Co. and comes to us from the Blaw-Knox Co. of Pittsburgh, Pa., where he was Vice President in charge of Engineering and Sales of the Power Piping Division. Well known in the Engineering and Sales field he is a national authority on Power Plant Design and Operation, an inventor and author of numerous technical contributions

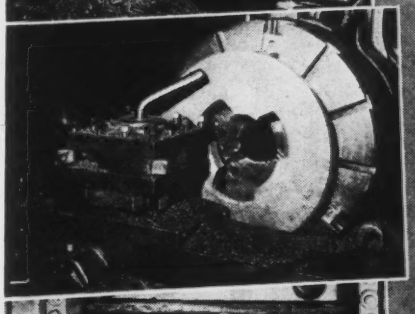
Continued on Page 52

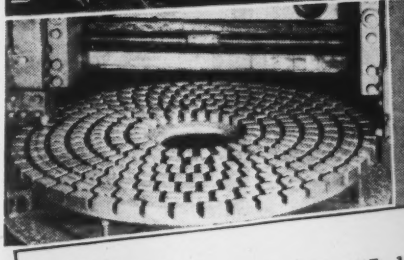
Scores of Tough Jobs Prove

KENNAMETAL K6 Machines CAST IRON

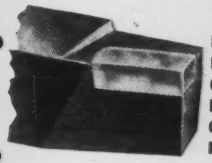
with Maximum Economy





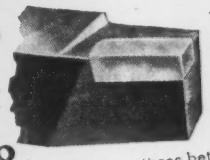


Kennametal Grade K6 is one of the most useful and needed recent developments in tool materials for machining cast iron and non-ferrous metals. It is an improved tungsten carbide having unusual strength in combination with exceptional abrasion-resistance and high hardness. The four performance studies outlined below are typical of scores of comparative service results that clearly show the superior properties of K6 for interrupted and continuous cutting on cast iron.



REMOVES TONS OF METAL FROM CHILLED CAST IRON PARTS, AT TOOL COST OF 74 CENTS PER TON

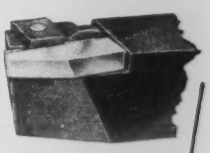
Style 12 Tool with K6 tip turns 1½ lineal miles between grinds! Other makes of carbide failed at all speeds and feeds. After 10 regrinds K6 tip is used on lighter jobs. Operation—turning cast iron piston trunks, 21½" diameter, having six 3" or 4" ports (interrupted cut). Chilled around port holes. Very sandy surface. Feed—.09375". Depth of cut—½". SFM-120.



TURNS OUT 10 TIMES AS MANY PIECES, ON ROUGH CASTING, BETWEEN REGRINDS

One to four pieces between grinds was the best performance recorded by other carbides on machining a webbed flange of inferior grade cast iron, having hard spots, and sand pockets. K6 turns out more than 40! Operation—turning outside diameter and facing both sides of hub and rim. Feed—.032". Depth of cut 1/16" to 3/8". SFM-280.

MULTIPLIES OUTPUT, ON FACING OPERATION, ON SANDY IRON CASTING

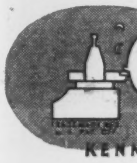


Replacing another make of carbide with a Style 11HD Tool having a clamped-on, advanceable K6 tip, made possible tripling the feed, doubling the cutting speed, and facing 8 times as many pieces per regrind. Operation—facing sandy iron castings. Feed—.036". Depth of cut—1/8" to 3/16". SFM-150 at start, 320 after tool entered cut.

The best way to prove that K6 makes possible better, faster machining on cast iron, at lower tool costs, is to try it in your own shop—then compare tool performance and overall costs. Order a few Kennametal blanks, or complete tools, now—and ask our district field engineer, who is fully acquainted with the properties of K6, to help you get maximum results from this new and improved tungsten carbide—Kennametal Grade K6.

CUTS 35 PIECES (on Abrasive Electric Iron) AS AGAINST 3 FOR CARBIDE PREVIOUSLY USED

This unique tool, tipped with Kennametal K6, turns out 11½ times as much work between grinds as the carbide tool previously used. Operation—finish trepanning cut on electric iron part. Feed—.003". SFM-210. Accurate tolerances and good finish required, and produced.



KENNAMETAL

SUPERIOR CEMENTED CARBIDES

KENNAMETAL Inc., LATROBE, PA.

as published by The Detroit Edison Co., Blaw-Knox and others. He is an alumnus of the University of California and a member of the ASME.

The establishment of this office is particularly important and in keeping with their "Advanced Engineering Products"—this form of progress will better enable them to place at your disposal all of their engineering and research experience and the facilities associated with their Modern Plants and manufacturing equipment.

Certified Gauge Acquired by American Chain & Cable

American Chain & Cable Co., Inc., Bridgeport, Conn., has acquired the business of the Certified Gauge & Instrument Corp., of Long Island City, N. Y. The principal product of the latter company is a pressure gage with a new patented mechanism called the Helicoid movement. This gage was developed during the war and is used widely by the Army and Navy. Manufacturing will continue at the Long Island City plant under the name Helicoid Gage Div., American Chain & Cable Co., Inc. As Helicoid Gages are used in the same general fields as two of American Chain & Cable's present lines, Reading-Pratt & Cady Valves and d'Este Automatic Regulating Valves, the acquisition of this new line will supplement the Company's products for markets it now serves.

Tofte New Manager of Allis-Chalmers Advertising and Public Relations Department

Arthur R. Tofte has been named manager of the advertising and public relations department, Allis-Chalmers Manufacturing Co., by William C. Johnson, vice-president of the firm's general machinery division.

Tofte has been a member of the department since 1938. He succeeds George J. Callos, who resigned to become vice-president and account executive for Klau-Van Pieterson-Dunlap Associates, Inc., Milwaukee advertising agency.

The new manager entered the department as copy chief. He became director of employe publications in 1942 and held that position until he was selected to head the department.

Tofte entered the advertising field in 1925 after graduating from the University of Wisconsin. He has served in copy departments of several advertising agencies and also as advertising manager of the Sterling Motor Truck Co. He was a member of the advertising department, Bucyrus-Erie Co., immediately before going to Allis-Chalmers.

Nordberg Appoints Cox Pacific Coast Manager

Nordberg Mfg. Co. announces the appointment of C. G. Cox as Pacific Coast Manager of its Heavy Machinery Division for such Nordberg products as Diesel and Steam Engines for marine and stationary service, mine hoists and compressors. Mr. Cox is well known to users of Diesel equipment particularly on the Pacific Coast because of his years of association with Diesel engine industry. He will be located at the present San Francisco offices of Nordberg, at 55 New Montgomery Street.

George Lienhard in charge of service and installation for Nordberg on the Pacific Coast will continue in that capacity with the same headquarters at the above address.

Sales and service for the Crusher Division of Nordberg remains at its present location in the Subway Terminal Building, Los Angeles under the jurisdiction of T. D. Davis, Pacific Coast representative of this Division.

Wickwire Spencer Appoints Rollo New England District Manager

The Wickwire Spencer Steel Div., Colorado Fuel and Iron Corp., announced the appointment of Herbert D. Rollo as New England District Sales Manager.

Mr. Rollo has been connected with Wickwire Spencer since 1933. He has been stationed in Chicago and in New York as Wire Rope Sales Engineer. Prior to 1933 he was with the American Chain and Cable Co. in the Engineering Department.

In his new position Mr. Rollo will have full charge of all sales operations throughout New England. Currently Wickwire Spencer is expanding its sales activities and developing new and wider postwar markets throughout the New England area in which several of the company's plants and fabricating mills are located.

Mr. Rollo will make his headquarters at the New England District Office, 80 Federal Street, Boston 10, Mass.

Gerotor Appoints Garco Cleveland Representative

Gerotor May Corp., Logansport, Indiana, announces Garco Machinery Co., Cleveland, Ohio, as representative in that territory for Gerotor Air and Hydraulic Valves and Cylinders and Hydraulic Pumps.

Garco personnel has had long experience in the pneumatic and hydraulic field and now with the addition of the Gerotor line are still further qualified to handle the power needs of Cleveland manufacturers.

Smith Appointed Director of Quality for Tube Turns

Harry G. Howell, vice president in charge of production of Tube Turns, Inc., Louisville, Ky., has announced the appointment of Fred C. Smith as Director of Quality.

A native of Marion, Ind., Mr. Smith acquired his B.S. and Ch.E. degrees at Purdue and began his administrative career as plant metallurgist with International Harvester in Fort Wayne and Chicago. Prior to joining Tube Turns in January, 1943, as chief metallurgist, he was field metallurgist for Carnegie-Illinois. He is a member of the

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American Society for Metals; the American Society of Automotive Engineers; the American Welding Society and other technical bodies, and of two honorary fraternities, Tau Beta Pi and Phi Lambda Upsilon.

Evans Appointed Chief Metallurgist for Elliott Co.

The appointment of Charles T. Evans, Jr., as chief metallurgist for the Elliott Co., Jeannette, Pa., is announced by R. B. Smith, engineering vice president.

Evans, formerly manager of the carbide department of the Titusville plant of the Universal-Cyclops Steel Corp., has been concerned with the development of high temperature resistant steels for application to high-temperature steam and refinery valves, turbochargers, jet and rocket propulsion equipment. Another of his developments was a method for providing tungsten carbide bullet cores which, mounted in shells, were effective in stopping German tanks.

One of the active organizers of the Northwestern Pennsylvania chapter of the American Society of Metals, Evans has, since 1941, served as a member of the National Advisory Committee for Aeronautics.

In his new assignment he will be responsible for the metallurgical problems of the whole Elliott Co., with particular attention to the metallurgical aspects of research and production of gas turbines.

Randlett Appointed by Pittsburgh Plate Glass

Milwaukee, Wis.—M. R. Randlett has been appointed Assistant Divisional Director of Pittsburgh Plate Glass Co.'s Milwaukee paint factory.

Upon his graduation from Rice Institute in 1922 Randlett joined the Company at its Houston branch. After serving as a territorial salesman he was appointed Paint Manager at Houston in 1925. In 1929 he was named Assistant Trade Sales Manager of the Newark paint factory; in 1930 he moved to the Milwaukee plant to serve in the same capacity. Since 1932 Mr. Randlett has been manager of Trade Sales at the Milwaukee paint plant.

Boomer Elected President of Tube Turns

George O. Boomer, longtime associate of the late Walter H. Girdler, Sr., founder of Tube Turns, Inc., Louisville, Ky., was elected president of the firm at a recent meeting of the board of directors. He was vice president of Tube Turns when Mr. Girdler died suddenly last January.

Mr. Boomer succeeds Rudy E. Fritsch, who resigned early in October. Mr. Fritsch will remain with Tube Turns as a consultant, for the present.

Changes in Briggs Clarifier Ohio Offices

Willis Engineering Co., Ohio distributors for Briggs Clarifier Co. oil filtration products (industrial) recently announced that their general offices have been moved to Burton, Ohio, and that a new office has been opened in Cleveland (206 Plymouth Bldg.).

This Ohio firm has been a franchised distributor for Briggs Oil Clarifiers and Filters since January 1944.

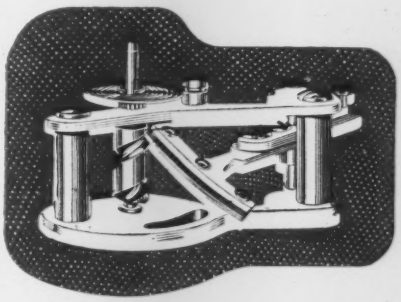
John B. Willis, President and General Manager is well known throughout the State and in the industrial field as a thoroughly competent industrial products man.

At the present time, the company operates from the following office locations: Cincinnati—1298 Michigan Avenue; Cleveland—206 Plymouth Bldg.; and Burton, Ohio (general business office).

Continued on Page 54

AMERICAN CHAIN & CABLE CO., INC. has acquired the business of the Certified Gauge & Instrument Corp.

The Certified pressure gage, which has proved to be so revolutionary because of the Helicoid movement, will hereafter be manufactured by American Chain & Cable. For the sake of clarity, this precision instrument will be known as the Helicoid Gage.



The Helicoid movement is used exclusively in Helicoid Gages

The outstanding performance of the Helicoid Gage will be even further improved by the engineering ability and experience of American Chain & Cable.

If you are not now using Helicoid Gages and if you desire to reduce your gage maintenance cost, order them the next time.

See your nearest Distributor.

ACCO

34-18 Northern Boulevard, Long Island City 1, N. Y. • Bridgeport, Conn.

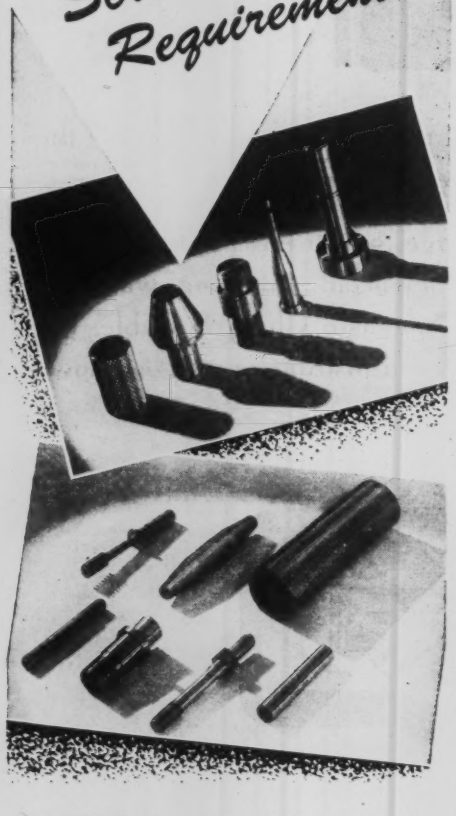
TRADE MARK

HELICOID GAGE DIVISION
AMERICAN CHAIN & CABLE

In Business for Your Safety

MAY WE QUOTE YOU

On Your Screw Machine Requirements



This screw-machining plant can become an important department of your factory—through quick service of your requirements for such parts—precision-machined to perfection for immediate trouble-free assembly. Secondary operations such as heat treating, grinding, drilling—almost any processing operations you specify are obtainable here. Send your blue prints for quick quotations.

AMON-SCHULTE CO.

Emsworth, Pittsburgh 2, Pa.

ASCO QUALITY

• Keep Informed . . .

Austin Appointed Wickwire Spencer Wire Rope Distributor

L. R. Austin of Billings, Montana, has been appointed distributor for Wickwire Spencer Wire Rope in Montana, Wyoming and Idaho, according to an announcement by Mr. A. S. Rairden, Sales Mgr., Wire Rope Department.

Austin will stock inventories of Wickwire Spencer Wire Rope for the oil fields and other industries at Billings and Cut Bank, Montana, and at Casper, Wyoming. Stocks at these strategic points will enable Austin to offer immediate service on all requirements.

Headquarters and main sales offices of L. R. Austin will be located at Billings.

W. S. Yunker Added To Foxboro Co. Staff

The Foxboro Co., Foxboro, Mass., maker of industrial instruments for measurement and control, announces that Ward S. Yunker has joined the Company, at the Home Office, as Assistant Manager of the Fiber Industries Sales Division, specializing in instrument engineering for the pulp and paper industry.

This type of work is in line with Mr. Yunker's extensive experience, his past connections having been with the Great Northern Paper Co., the Paper Insulated Wire Division of the Western Electric Co., and the Roofing Products Division of the Flintkote Co. At Middlebury College, where he had majored in industrial chemistry, he graduated with the degree of B.S. He then took a position in the Forest Products Laboratory of Department of Agriculture, at the University of Wisconsin, and followed this with post-graduate work at the Institute of Paper Chemistry, at Appleton, Wis.

Since joining The Foxboro Co., Mr. Yunker has been busy with problems of instrumentation for the new equipment, and new or expanded mills, now contracted for or in the blueprint stage, throughout the pulp and paper industry.

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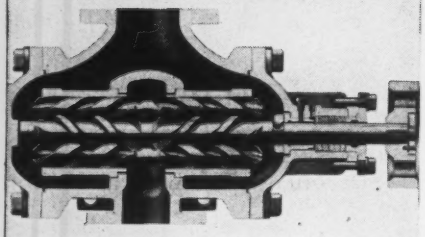

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For further information write for catalog I-127-A

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Burgoyne Appointed By Federal Products

William L. Burgoyne has been appointed Special Field Engineer for the Federal Products Corp., Providence, R. I.

He was previously Assistant to the General Manager of Wright Aeronautical Corp. of Paterson, N. J., on special assignments.

Prior to 1942 he was Methods Engineer on Aircraft for the Brazilian Government, and earlier was Methods Engineer on General Manufacturing for Sperry Gyroscope Co., Inc.

Tippery Work Manager of Morse Chain Ithaca Plant

Frank M. Hawley, vice president and general manager of the Morse Chain Co., Ithaca, N. Y., and Detroit, Michigan, Division of Borg-Warner Corp., announces the appointment of Mr. Frank C. Tippery as works manager of the Ithaca plant. Mr. Tippery comes to Morse Chain Co. from the Ford Motor Co. where he has acted in many capacities, particularly on production problems and the supervision of tools and dies, gauges and production equipment.

During the past two years Mr. Tippery assisted the purchasing department, contacting many Ford suppliers on tooling up the Ford bomber plant and the Highland Park plant where the Sperry gyroscope project was developed. During the war he also acted as supervisor of inspection on Pratt & Whitney engines.

Dr. William T. Griffiths, of London, Names A Vice-President and Director of International Nickel

Dr. William T. Griffiths, of London, has been elected a Vice-President and Director of The International Nickel Co. of Canada, Limited, Robert C. Stanley, Chairman and President, announced after the directors' meeting recently. In both these offices, he succeeds the late David Owen Evans, Liberal Member of Parliament for Cardiganshire, North Wales, from 1932 to the time of his death on June 11, last.

He is Chairman of The Mond Nickel Co., Ltd., the British affiliate of International Nickel. Joining Mond in 1926, Dr. Griffiths had been manager of its Development and Research Department since 1928. He is President of the Institute of Metals of Great Britain.

W. A. Elliott Elected President of Elliott Co.

Grant B. Shipley, chairman of the Board of Elliott Co., Jeannette, Pa., announces that at a meeting of the Board of Directors, W. A. Elliott was elected president. Mr. Elliott has been executive vice-president. Mr. Shipley, who remains as chairman of the Board, previously was also president.

F. H. Stohr, formerly assistant to the president, was elected executive vice-president and F. W. Dohring, who has been general sales manager, was elected vice president in charge of sales.

Other executive officers of Elliott Co. include: R. W. Owens, vice-president in charge of manufacturing, R. B. Smith, vice-president in charge of engineering, Dundas Peacock, controller, and M. G. Shevchik, secretary and treasurer.

• Keep Informed

Swanson Appointed Hedstrom Sales Manager

Gustav S. Swanson has been appointed sales manager of the Oscar W. Hedstrom Corp., Russell W. Hedstrom, president of the company, recently announced.

A resident of Chicago since 1930, Swanson has served in a similar capacity with the Pettibone Mulliken Corp., the Crocker-Wheeler Electric & Manufacturing Co., the Wellman Engineering Co. of Cleveland, the Sullivan Machinery Co. of Michigan City, Ind., and the Universal Scaffolding Co. of Zelienople, Pa.

Swanson attended the University of Illinois. His education was interrupted by World War I, in which he served as gas defense officer with the 33rd division overseas.

Swanson is married and he lives at 704 North Mayfield Avenue.

L. D. T. Berg Appointed Welding Specialist General Electric's Atlantic District

L. D. T. Berg, for the past five years a sales engineer in General Electric's Electric Welding Division, Schenectady, has been appointed welding specialist of the Company's Atlantic District with headquarters in Philadelphia, according to an announcement by K. H. Runkle, manager of the G-E Industrial Divisions.

Mr. Berg, a native of Sparta, Wis., was graduated from the University of Wisconsin in 1937 with the degree of B.S. in electrical engineering and immediately joined General Electric as a student engineer. After taking the Test Course in Milwaukee, Schenectady, and Pittsfield, Mass., he was transferred in December, 1938, to the International General Electric Co., Inc.

In September, 1940, he was named a sales engineer in the G-E Electric Welding Division, reporting to C. I. MacGuffie, manager.

Mr. Berg is a member of the American Welding Society and the American Institute of Electrical Engineers.

McColl Elected American Locomotive Executive Vice President

Election of Robert B. McColl as executive vice-president of American Locomotive Co. was recently announced by Duncan W. Fraser, president. Mr. McColl is succeeded as vice-president in charge of manufacturing by W. L. Lentz of Schenectady who directed the company's vast tank and locomotive manufacturing program there the past five years.

Mr. McColl has the distinction of being one of the few American members of the Institute of Mechanical Engineers, London, and has been engaged in locomotive manufacture since boyhood when he started as an apprentice with the Glasgow and Southwestern Railroad in Scotland.

After a period with the original builder of the steam locomotive, Robert Stephenson & Sons in Darlington, England, he went with the Montreal Locomotive Works in Canada, an affiliate of American Locomotive Co. After World War I he was with the Armstrong Whitworth Co. in England but soon returned to this side with American Locomotive Co. as assistant manager of the Schenectady works.

He has since been successively manager of this plant, president of the company's diesel engine manufacturing division, known as the old McIntosh and Seymour Corporation, president of the Alco Products Division of the company, and vice-president in charge of manufacturing for the locomotive company.

Continued on Page 56

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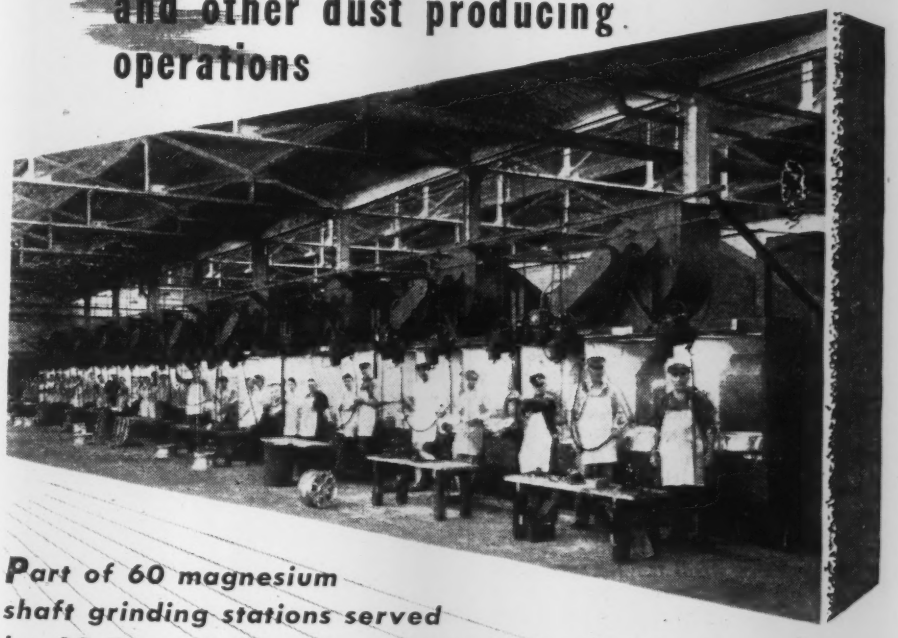

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• Finely divided dusts produced by grinding and finishing operations on metal parts, plastics and other materials are particularly suited to collection by the Type N Roto-Clone. *This wet-type dust precipitator is available in 2 forms—as a complete self-contained unit and as a ventilated bench (illustrated above). In this installation 3 grinding stations are served by each Roto-Clone—thus requiring a total of 20 dust collection units. These units exhaust an air volume of 120,000 C. F. M. which is recirculated clean to the workroom. Send for Bulletin No. 277 for further information.

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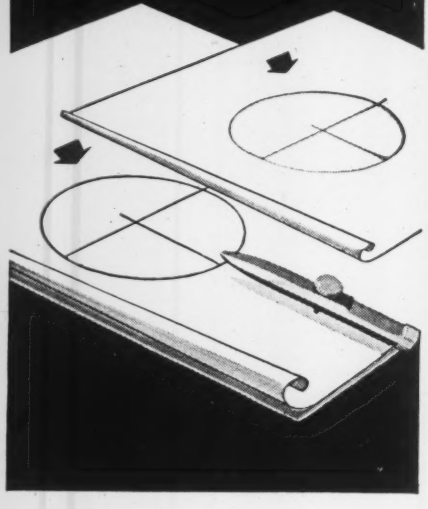
Tracing cloth that defies time



• The renown of Imperial as the finest in Tracing Cloth goes back well over half a century. Draftsmen all over the world prefer it for the uniformity of its high transparency and ink-taking surface and the superb quality of its cloth foundation.

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During the war period, he directed the company's huge war production program, which included tanks, gun carriages, locomotives, synthetic rubber refining equipment, bomb casings, shells, Navy forgings, and, most recently, materials for the atomic bomb project.

Mr. McColl was educated at Kilmarnock Academy and the Science and Art College, in his native Kilmarnock, Scotland.

Mr. Lentz, formerly with the New York Central System, took over the management of the Schenectady plant at the outset of the war and supervised the conversion of the plant from its exclusive locomotive buildng operations to what was at one time the country's second largest tank producing arsenal. Through the individual skilled resources of the locomotive workers, this plant built the first M-3 medium tank to be produced by private industry in the United States. This plant likewise built all of the tank killers used by Montgomery in routing Rommel at El Alamein.

An aviation cadet and artillery officer in the last war, Mr. Lentz began railroading in 1913 with the New York Central. For an interval after 1937 he was sales manager of the Standard Stoker Co.

American Locomotive Co., which operates 10 plants in this country and Canada, has headquarters at 30 Church Street, New York.

U. S. Gauge Co. Announces Appointments Forecasting Sales

As part of the plan to enlarge the sales organization of the United States Gauge Co., J. Newton Becker, Vice-President in charge of Sales, Engineering and Research, announces the promotion of W. S. O'Connor to National Field Sales Manager to assist L. L. Corcoran, Sales Manager. H. M. Baer will succeed Mr. O'Connor as District Manager of sales territory covered by the New York office.

In view of the trend of orders received during the past few months from industries requiring United States Gauge instruments, Mr. Becker predicts that the company expects to maintain a sales level equal to twice that of the immediate pre-war dollar volume.

Tooling of newly designed instruments is being completed and it is expected that the first modernized gauge will roll off the production line within a few weeks. Experimental, metallurgical and research facilities are being expanded and moved to new air conditioned quarters under the direction of A. E. LeVan, head of research and development.

Dr. T. H. Troller Returns to La-Del After Completing European Assignment for U. S. Government

Completing a special assignment for the U. S. Government in Europe, Dr. T. H. Troller, developer and pioneer of the axial air flow principle, returns to his activities as Consulting Engineer of The La-Del Fan Co., Division of The La-Del Conveyor & Manufacturing Co., New Philadelphia, Ohio. On leave from La-Del, Dr. Troller made a special study of the most recent aeronautical developments in Europe.

Dr. Troller, Research Director for the Daniel Guggenheim Airship Institute, has been prominent in the development of La-Del Axial Flow Fans and was instrumental in creating the design accepted by the U. S. Navy as the answer to the problem of providing top efficiency in ship ventilating systems. As Chief Engineer for La-Del, Dr. Troller will continue the development of new applications for the La-Del Axial Flow Fan, which already has been successfully applied to the

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marine, aviation and industrial fields. Based on design and production experience gained by the company during its period of work for the Armed Forces, many interesting innovations are expected to find the La-Del Axial Flow Fan of the future providing economical, efficient ventilation in a variety of applications.

Chiksan Appoints Texas Representative

Chiksan Co., manufacturers of Chiksan Ball-Bearing Swivels, Brea, California, announces the appointment of Well Equipment Manufacturing Corp., Houston, Texas, as exclusive Chiksan representatives for the states of Texas, Oklahoma and Kansas and portions of Mississippi, Arkansas and New Mexico.

Well Equipment Manufacturing Corp. will handle the distribution of Chiksan Ball-Bearing Swivels to the Petroleum Industry and to Industry in general in this area. The members of the "Weco" organization are thoroughly experienced in this line as Well Equipment Manufacturing Corporation has already served successfully for a number of years as Chiksan distributor in portions of the larger territory which it now covers.

Physicist Heads New Westinghouse Western Laboratory

Dr. Russell A. Nielsen, a native of Portland, Ore., and formerly a research engineer for Westinghouse at East Pittsburgh, Pa., heads the new Pacific Coast High Frequency Laboratory opened recently by the Westinghouse Electric Corp.

Dr. Nielsen was born in Portland, Ore., and is a son of R. A. Nielsen, of 903 N. E. Prescott St., Portland attorney, and Mrs. Nielsen. He attended Highland Grammar School and Jefferson High School, Portland, and graduated from Stanford University, California, in 1933 with a Bachelor of Arts degree in physics. He won his Master's degree at Stanford in 1934, and his Doctor's degree there in 1937, then joined the Westinghouse research staff.

The physicist holds membership in the American Institute of Electrical Engineers, the American Physical Society, Phi Beta Kappa honorary scholastic fraternity, Sigma Xi honorary physical fraternity, and other organizations.

Dr. and Mrs. Nielsen and their son, Norman, will establish their new home soon at 2057 Meridian St., South Pasadena, California.

Foxboro Adds Tivy In Oil and Gas Division

The Foxboro Co., maker of industrial instruments for measurement and control, announces the appointment of V. V. St. L. Tivy, as Assistant Manager, Oil and Gas Industries Sales Division. He has already entered upon his new duties, at the Home Office of the Company, at Foxboro, Mass.

Mr. Tivy has had unusually broad experience in the construction, operation and instrumentation of oil refineries and related industrial plants. After graduation from the Royal Naval Academy, in England, in 1933, and two years of sea duty as a junior engineering officer in the Royal Navy, he joined an English firm of instrument makers, and later the Neal & Massy Engineering Co., Ltd., at Trinidad, B. W. I. His work there led to a connection with the M. W. Kellogg Co., with whom he spent several years, before joining The Foxboro Co.

His familiarity with refinery processes and operations has equipped him for services of particular value in the field of instrument engineering for the oil and gas industries.

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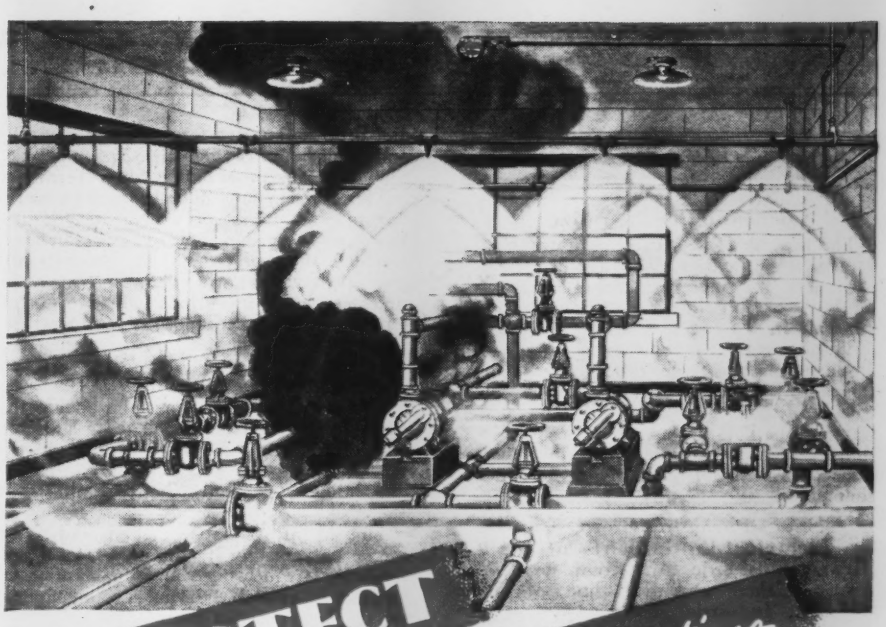

The resultant damage from a fire in this pumping station must be calculated, not only in terms of actual physical loss but also in terms of losses resulting from the interruption to plant operations.

Whether started from a cracked fitting, faulty pump packing, leaky flange or similar cause—fires of this type have sent flames rocketing to alarming proportions and intensity within the space of a moment.

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• LATEST CATALOGS

Cochrane Demineralizers

The process of preparing clear water, the equivalent of commercially distilled, by ion exchange, is described in Cochrane Corporation's new Bulletin 4181—"Cochrane Demineralizers."

This new and revolutionary method of preparing clear water for process offers opportunities of economies and improved products wherever there is a need for mineral-free water. The bulletin describes the process in simple language, accompanied by illustrations and chemical reactions of the ion exchange process.

Paragon Offers Electrical Equipment Catalog

Paragon Electric Co.'s complete catalog covering their extensive line of Time Switches, Industrial Timers, Time Delay Relays and other time control instruments, contains a wealth of information on all of the above products. Each is completely described and illustrated, including detailed specifications and prices.

This two-color catalog is available to you upon request. Send your inquiry to the Paragon Electric Co., 37 West Van Buren Street, Chicago 5, Ill.

A New Glossary of Machine Shop Terms

Machine shop terminology as it applies to the machining of forgings has long been a subject which required clarification. To this end, Kropp Forge Co., 5301 W. Roosevelt Road, Chicago (50), Ill., producers of flat die, drop and upset forgings, has compiled and published a convenient 32-page booklet, the "Glossary of Machine Shop Terms."

This glossary is of definite practical aid to buyers and users of machined forgings. Words and terms are defined as used in heavy machine shop practice, and recognition is given the fact that other definitions are sometimes employed in various industries for describing identical processes or operations. The booklet will be mailed upon request.

Variable Speed Control

Reeves Pulley Co., Columbus, Ohio, has just issued a very small book about a big subject—Variable Speed Control for production machines.

Reading time is only about 12 minutes by the clock.

Slipped into your pocket and read on the street car, bus or train, or between conferences, it will bring you up to date on the equipment available to make your machines do the best possible job of turning out the products of war or peace.

It will give you a quick, renewed appreciation of the volume-increasing, quality-improving and money-saving advantages inherent in a machine that will operate at exactly the right speed for every changing condition, or job.

Portable A-C Test Sets

A new, 24-page bulletin, containing data and descriptive information on the complete line of portable, a-c test sets from 2000 to 150,000 volts, has been announced by the General Electric Co., Schenectady, N. Y. This attractive, well-illustrated bulletin enables the user of high-voltage testing equipment to compare the features and ratings of the various standard sets, and to select the equipment best suited to his individual requirements.

The portable equipments covered in the bulletin include small insulation testers, oil testers, and larger general-purpose test sets, with ratings as high as 25 kva.

In addition, the publication contains listings and description of sphere gaps and current-limiting resistance assemblies for use with a-c testing sets.

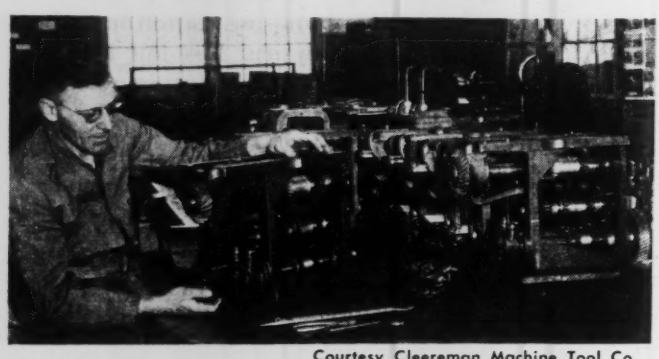
Copies of this new bulletin, GEA-4477, may be obtained from the General Electric Co., Schenectady 5, N. Y.

Pneumatic Transmission

A new 28-page Data Book No. 1000, entitled "Pneumatic Transmission" has just been issued by the Republic Flow Meters Co., 2232 Diversey Parkway, Chicago 47, Ill. It contains a comprehensive and well illustrated presentation of the principle of pneumatic force-balance and its use in industrial measuring instruments. The construction and operation of various types of pneumatic transmitters for the measurement of flow, pressure, level and density are fully described and illustrated. Copies of this new data book can be obtained upon request.

New Barnes Drill Catalog

Barnes Drill Co., Rockford, Ill., has issued a 12-page Condensed Catalog of its complete lines of metal working Drilling and Tapping Machines, Hydraulic Drilling Units, Vertical and Horizontal Hydraulic Honing Machines and its Magnetic-Automatic Coolant Separators, the latter for application to any machines using liquid coolants.



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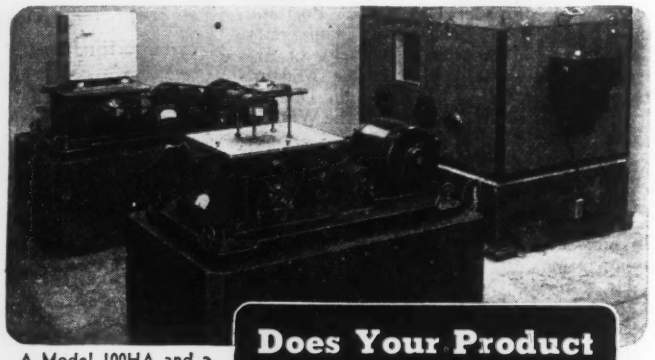

A Model 100HA and a Model 100VA in laboratory of Lord Mfg. Co., Erie, Pa., makers of vibration control equipment.

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CAN it stand up in today's competitive market? An All American Vibration Fatigue Testing Machine subjects parts, assemblies, and finished products to "shakedown" tests that prove their soundness or point the way to improved design. Widely used by aircraft, electronic and automotive equipment manufacturers. Eight models, handle parts from 10 lbs. to 100 lbs. Vibration produced in simple harmonic motion, vertically and horizontally. Frequency and displacement are adjustable. Send for Catalog "F."

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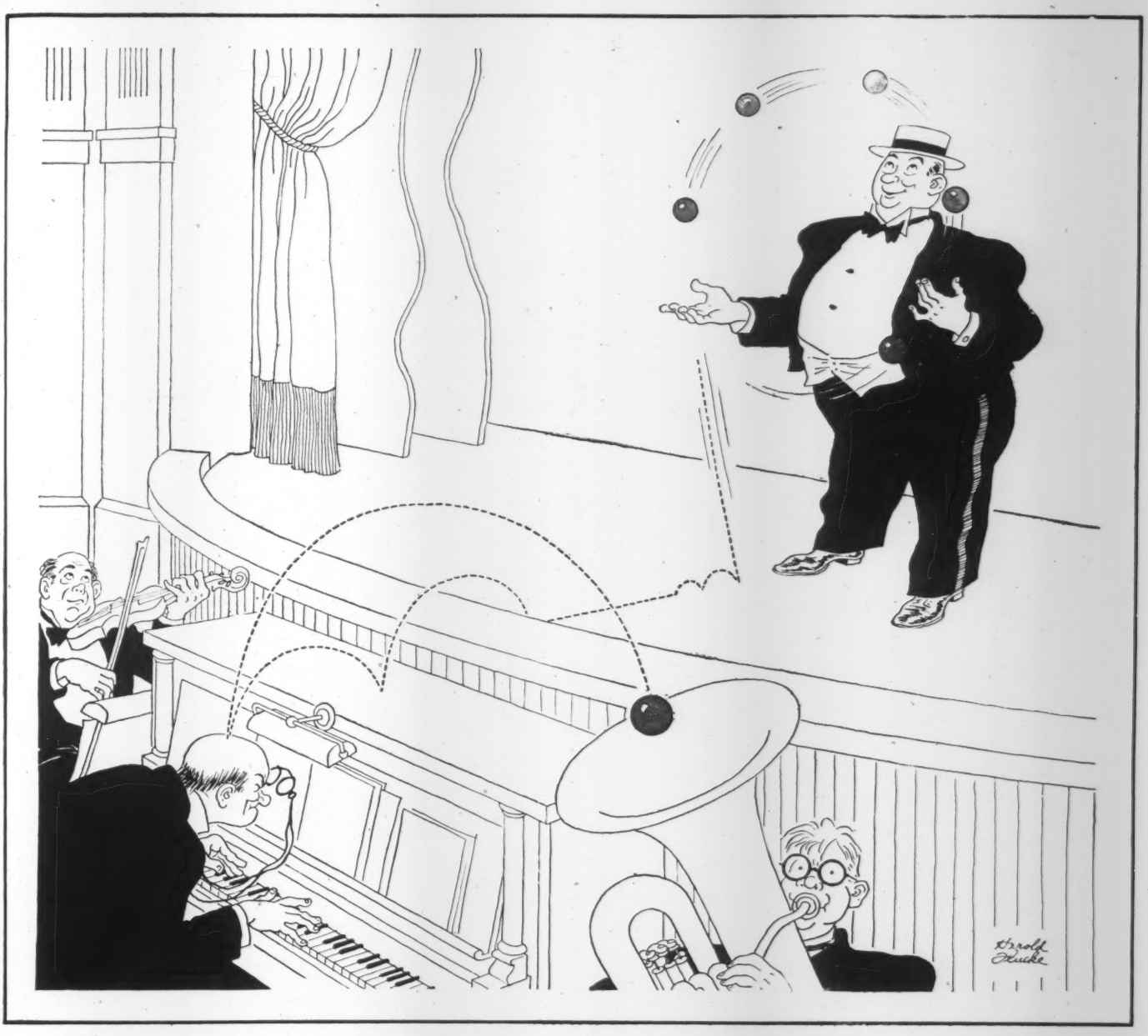

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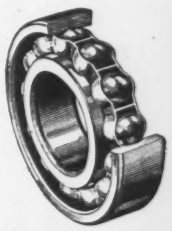

The engineering experience and meticulous manufacturing methods of New Departure, world's largest maker of ball bearings, can be of great advantage to you.

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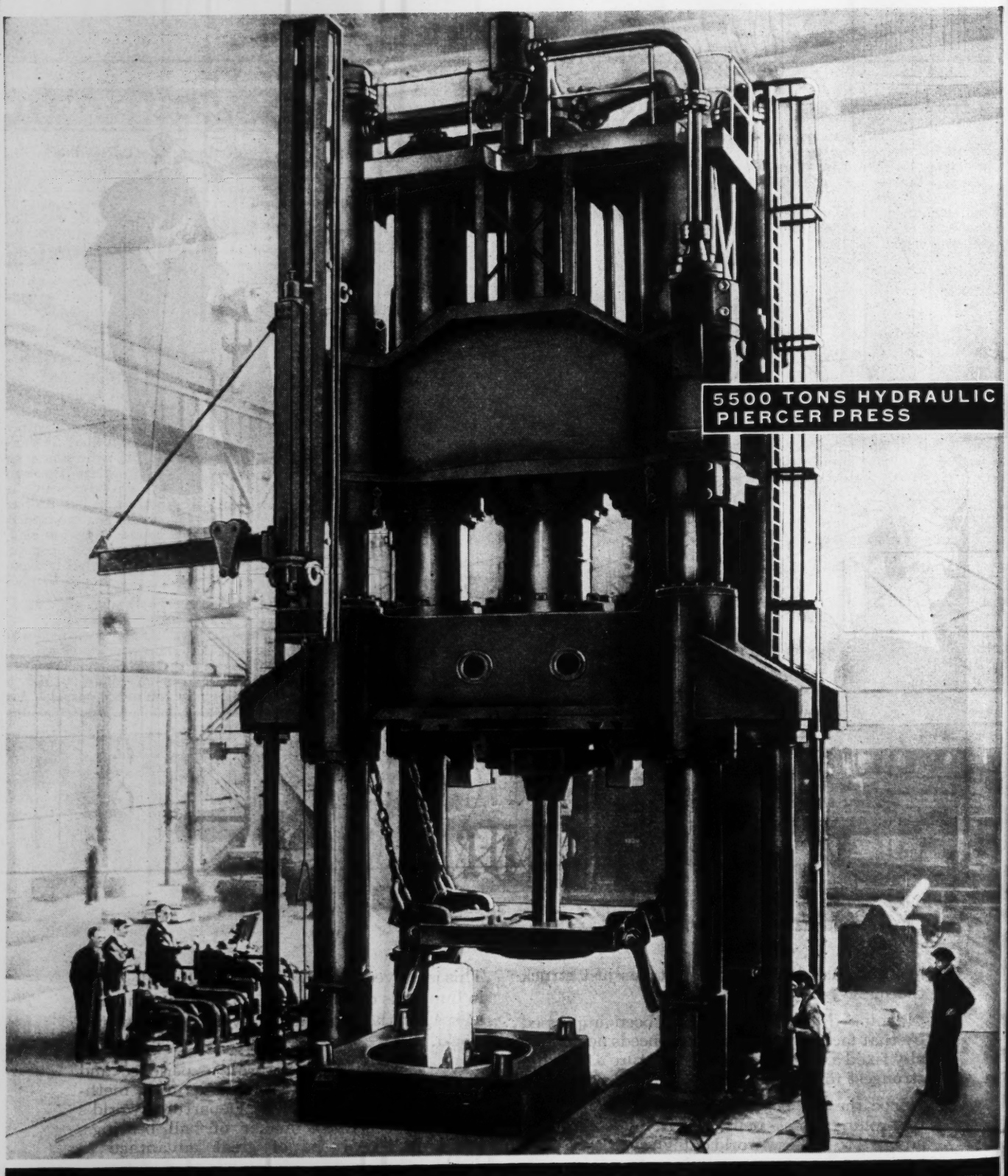

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Like the sun, the earth, the atom, the Wing Unit Heater REVOLVES. It keeps the heated air in gentle motion, slowly circulating a constant, uniform, EVEN temperature, transforming hot and cold spots into comfortable, energizing, productive areas. The circulating heated air from the slowly revolving discharges reaches to farthermost corners, gets around and under obstructions, eliminates hot spots and cold spots.

Install Wing Revolving Unit Heaters now. Not only will they heat your plant comfortably and evenly, bringing a sensation of fresh, live, invigorating warmth to workers, but in the Summer, with the steam turned off and the fans on, they create a pleasant, cooling air motion over the entire area.

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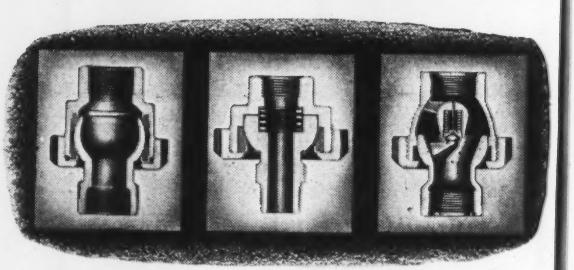
TURBINE BLOWERS · TURBINES · MOTOR DRIVEN BLOWERS · VENTILATING FANS · DUCT FANS · HEATING UNITS · SHIP VENTILATORS

Quick responsive movement is the natural safeguard against sudden strains and shocks. Barco Flexible Joints are designed to provide compensation for movement always present in fluid-conveyor systems...counteracting destructive vibration, expansion and contraction. Today, as for the past 30 years, engineers and designers throughout industry and transportation look to Barco for solution to their flexible joint problems. Write to Barco Manufacturing Co., Not Inc., 1807 Winnemac Ave., Chicago 40, Illinois.



BARCO **FLEXIBLE JOINTS**

Not just a swivel joint...but a combination of a swivel and ball joint with rotary motion and responsive movement through every angle.

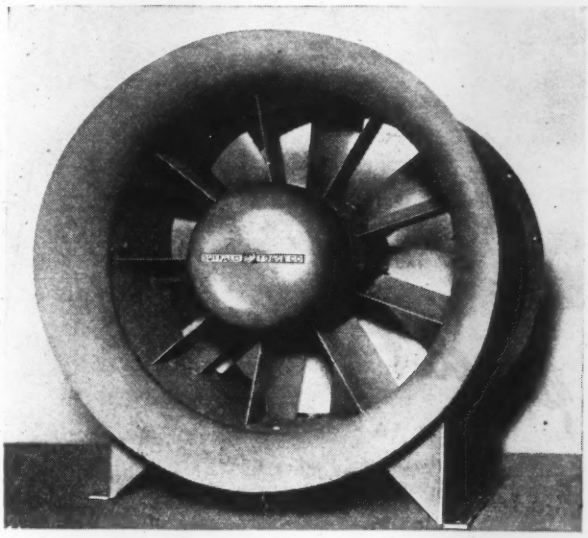
FREE ENTERPRISE—THE CORNERSTONE OF AMERICAN PROSPERITY

In Canada: The Holden Co., Ltd., Montreal, Canada

"MOVE IN EVERY DIRECTION"

All "Axials" are NOT alike

• All axial flow fans have certain advantages and disadvantages when compared to centrifugal fans on the same service.



For example—where a system has elbows or bad duc conditions near the fan inlet or outlet, a centrifugal fan will in most cases be a better selection. For handling dust-laden air, hot gases and corrosive fumes, centrifugals are generally preferable.

And, comparing Axials with Axials, there are some differences which are not at once apparent. In any propeller or axial flow type of wheel the air leaves the blades with a rotating, or screw motion. This is a characteristic of all propeller type fans and tends to increase when the fan is working against pressure. This swirling effect of the air leaving the fan means a drop in efficiency.

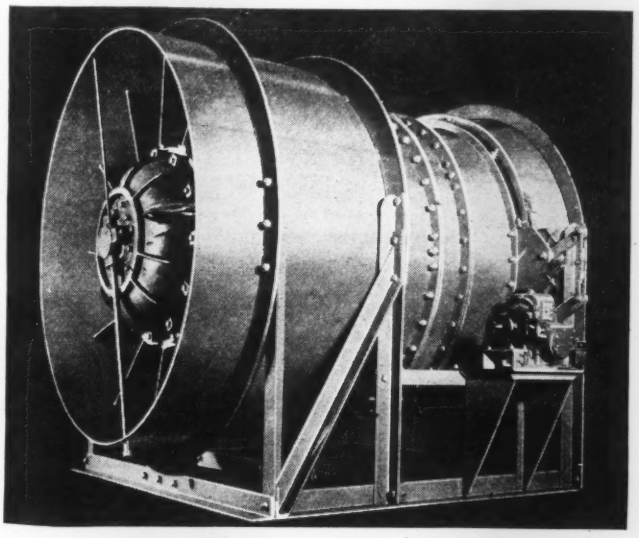
In Buffalo Axial Flow Fans a set of stationary curved vanes at the discharge side of the wheel correct this swirling motion of the air—deliver it in a "straight ahead" axial direction. Thus Buffalo Axial Flow Fans deliver full rated capacity in the system, and provide higher pressures than could be obtained at the same fan speed without vanes.

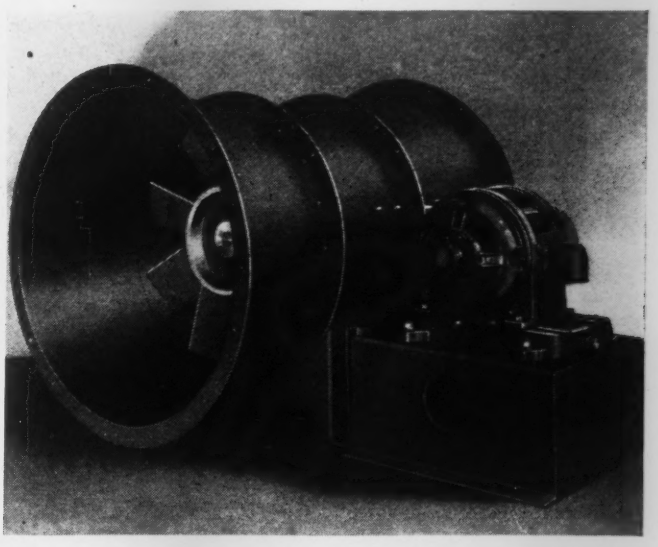
Users benefit by Buffalo's 67 years' experience in designing and building fans of all types.

BUFFALO FORGE COMPANY

148 Mortimer St. Buffalo, N. Y.

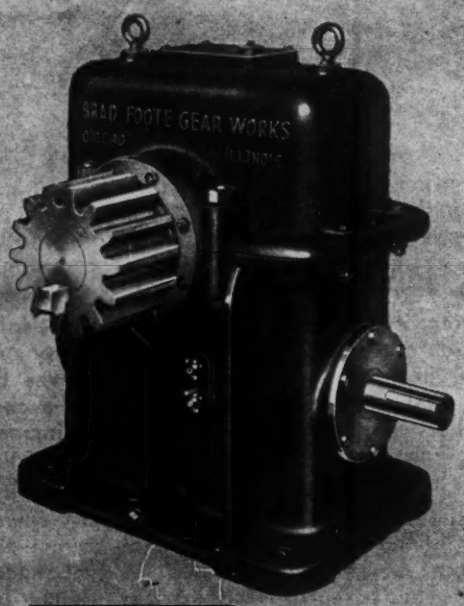
Canadian Blower & Forge Company, Ltd., Kitchener, Ont.





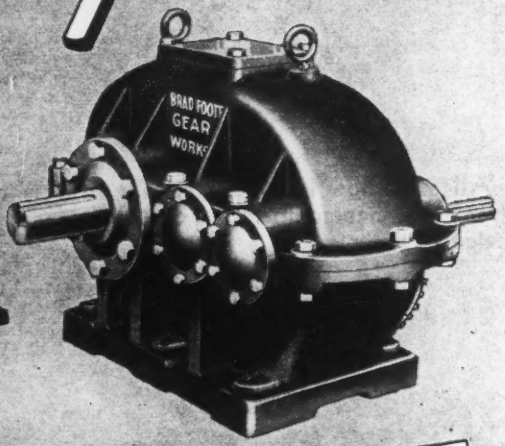
"Buffalo" **AXIAL FLOW FANS**

Brad Foote Gears



Worm Gear
3⅝:1 to 60:1

Helical Gear Vertical
2:1 to 80:1



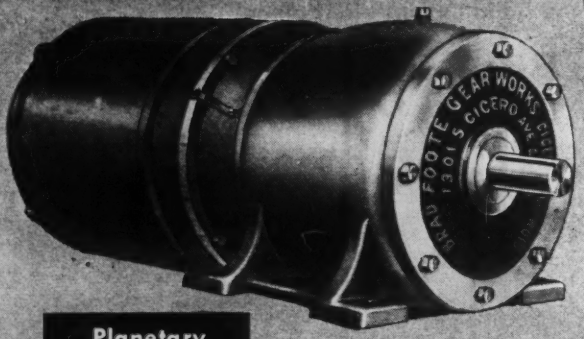
Herringbone Gear
2:1 to 295:1

Speed Reducers

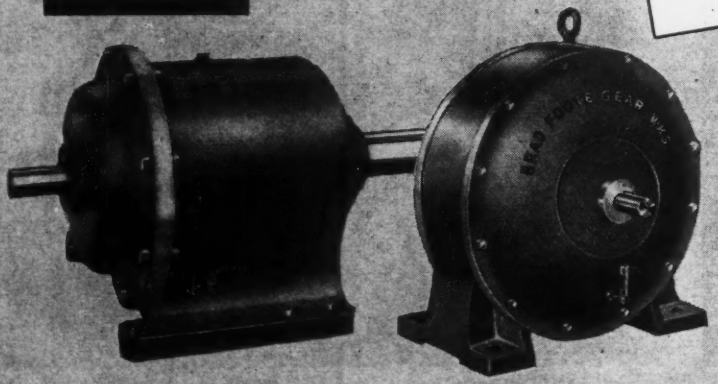
2:1 to 30,000:1

Brad Foote Speed Reducers made in all practical ratios employing every tooth form including bevels and spiral bevels have an exceedingly long record for continuous economical performance. All horse powers are available in this group of Brad Foote products—and all gears, shafts and parts are up to Brad Foote precision standards.

Write for Prices

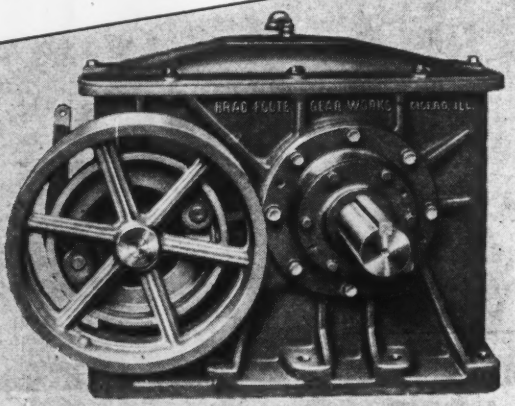


Planetary
4:1 to 400:1



Gyro
16:1 to 30,000:1

Spur
2:1 to 40:1



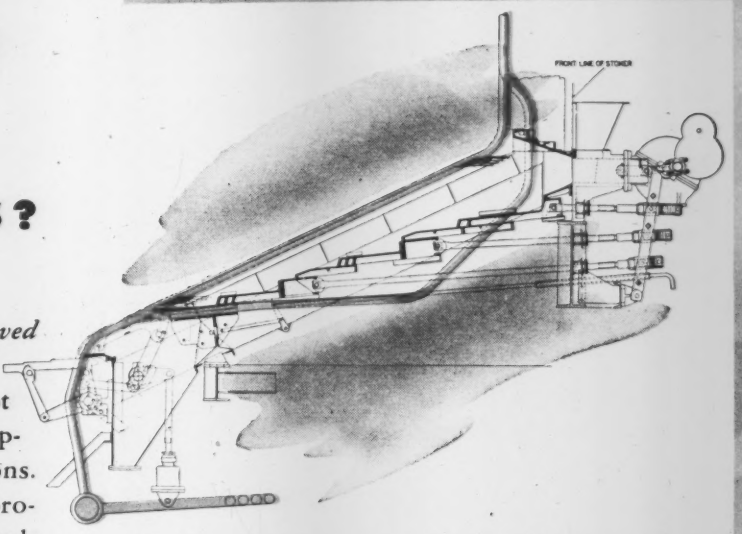
Oil Well Unit Little Giant
28:1

ARMY E NAVY

BRAD FOOTE GEAR WORKS

1309 SOUTH CICERO AVENUE
DEPARTMENT Y
CICERO 50, ILLINOIS

WILL THIS STOKER AFFECT YOUR FUTURE OPERATIONS?



PERHAPS you've heard about the *improved* Taylor Stoker—a time-tested stoker with outstanding *new* features that you should not overlook when selecting fuel firing equipment for your future power plant operations.

Precision control feed mechanism and provisions for better air flow mean more thorough combustion and minimum stack discharge. The stoker has simplified unit construction throughout with fewer moving, longer wearing parts. Continuous ash discharge and numerous other advantages are additional aids to efficient operation and low cost steam generation.

Examine *all* these features in the Type "R" Taylor Stoker booklet before you make *any* decision. A few minutes invested this way will pay dividends in worthwhile information. Mail your request to us *today.*

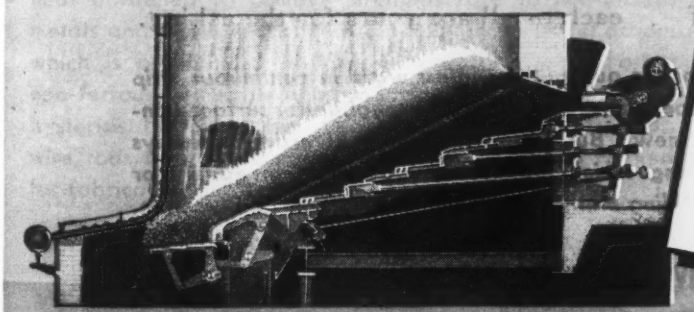
TYPE "R" WATER-COOLED TAYLOR STOKER has Important Operating and Maintenance Advantages

The Taylor Stoker is available with integral water tubes connected into the boiler circulation. This feature assures maximum fuel flexibility, higher operating efficiency and low boiler outage.

IF YOUR Steam Requirements Call for 20,000 to 500,000 lbs. per hour—

YOU NEED THIS BOOKLET

Write us. 2417 Aramingo Ave., Philadelphia 25, Pa.



Æ TAYLOR STOKERS

AIR-COOLED & WATER-COOLED

Other Æ Products: Æ-Perfect Spread Stoker, Lo-Hed Hoists, Marine Deck Auxiliaries, Hele-Shaw Fluid Power, Diamond Face Grinders

AMERICAN ENGINEERING COMPANY

PHILADELPHIA 25, PENNSYLVANIA

Copyright 1945, American Engineering Co.

Weather Beater

for the Voice-powered Telephone

THE sound power telephone, an instrument requiring neither batteries nor outside current for its operation, is one of the best of this war's brain children. Materialwise, however, it is something of a problem child.

Action with planes and ships exposes it constantly to the evils of the elements . . . especially corrosion. One of the largest manufacturers of sound power telephones—RCA Victor Division of the Radio Corporation of America—uses Riverside *Phosphor Bronze* for electrical contacts and springs, retaining spring for magnet and coil, switch blades and cable guard. Resistance to corrosion, electrical conductance, and ease of fabrication are good reasons why.

Let us tell you more about Riverside *Phosphor Bronze*, and *Nickel Silver* and *Beryllium Copper*, Riverside's 3 principal alloys. Catalogs on each or all are yours for the asking.

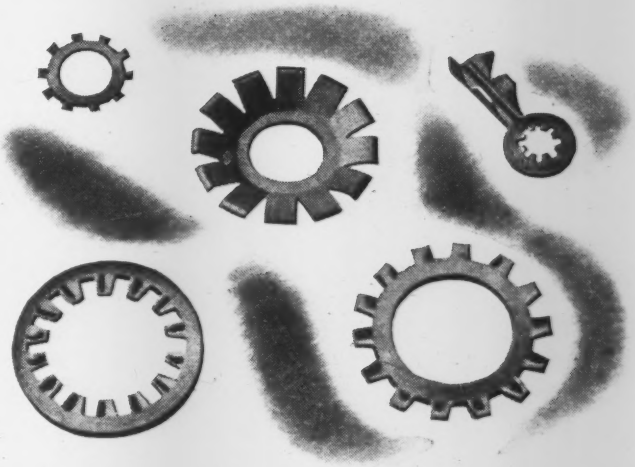
INSIDE RIVERSIDE—*Recently we put to work in our mill the latest word in continuous strip strand-annealing furnaces. From it you can expect more uniformity of anneal, better surface condition and closer gauge tolerances. This is news. But it's no news that Riverside is always looking for technical improvements. Anything which promises improvement in quality or in casting, rolling, drawing, annealing or pickling methods will get an audition at Riverside.*

RIVERSIDE

THE RIVERSIDE METAL COMPANY

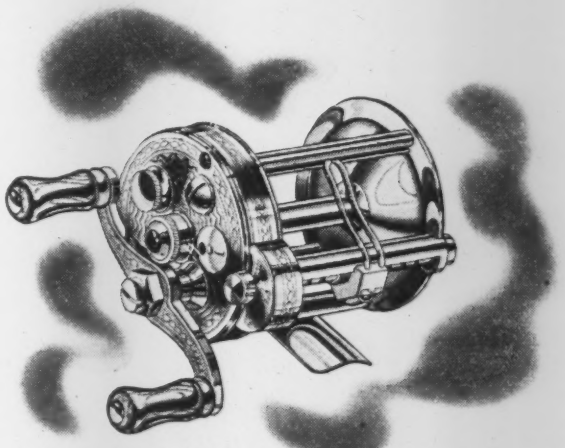
NEW YORK CHICAGO RIVERSIDE • NEW JERSEY HARTFORD CLEVELAND

RIVERSIDE PHOSPHOR BRONZE ALLOYS — Copper-tin alloys to which phosphorus is added. Made in variety of wrought and malleable alloys; special leaded mixtures; in non-malleable cast and turned rods for bearings and bushings. PROPERTIES—Wide range of tensile strengths and hardnesses. In general, phosphor bronze is a good electrical conductor, non-magnetic, and has a low coefficient of friction. It is easy to machine, can be welded by carbon or metal arc (there's a special alloy for flame welding), can be brazed or soldered. Easy to punch, draw, stamp, or spin. Phosphor bronze is rustless and resistant to corrosion, fatigue and wear. Supplied in sheets, strips, wire, rods, circles, bars, blanks or ingots.



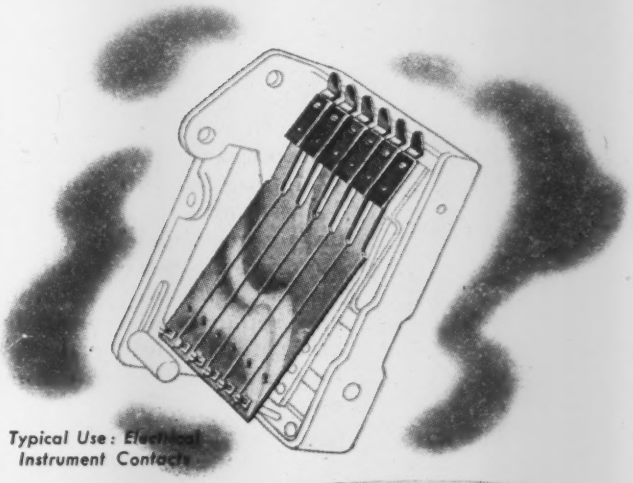
Typical Uses: Lock Washers

RIVERSIDE NICKEL SILVER ALLOYS — A combination of copper, nickel and zinc in various proportions. Made in variety of alloys, tempers, anneals; and in free-cutting alloys. PROPERTIES—Vary according to alloys. Tensile strengths up to 160,000 p.s.i., elongations up to 50%. Nickel silver is valued electrically for its spec fic resistance, and physically because of its clear-through silvery white appearance. In general, it is tough, resistant to wear, fatigue, and corrosion. Easy to machine in any manner, weldable by *all* methods, can be brazed or soldered and is extremely workable. Readily formed, bent, drawn, stamped, punched, embossed or spun. Supplied in sheets, strips, wire, rods, circles, bars, blanks and ingots.



Typical Use: Fishing Reel Parts

RIVERSIDE BERYLLIUM COPPER — an alloy with an unusual combination of properties — Unusually high strength. Excellent hardness, wear resistance and corrosion resistance. High thermal conductivity, good electrical conductivity. Easy to braze, solder, punch, draw or stamp. Can be cold worked. Outstanding for hot working qualities. Can be easily hot forged or hot pressed between 1050° and 1425°F., and heat hardened to achieve strengths rare to non-ferrous metals and alloys. Great resistance to fatigue under action, which is pronounced at high temperatures where other non-ferrous materials might fail. Negligible creep or hysterisis. Non-magnetic qualities. Supplied in sheets, strips, wire, rods, bars and blanks, usually, semi-hard, cold worked for fabrication and heat treatment.

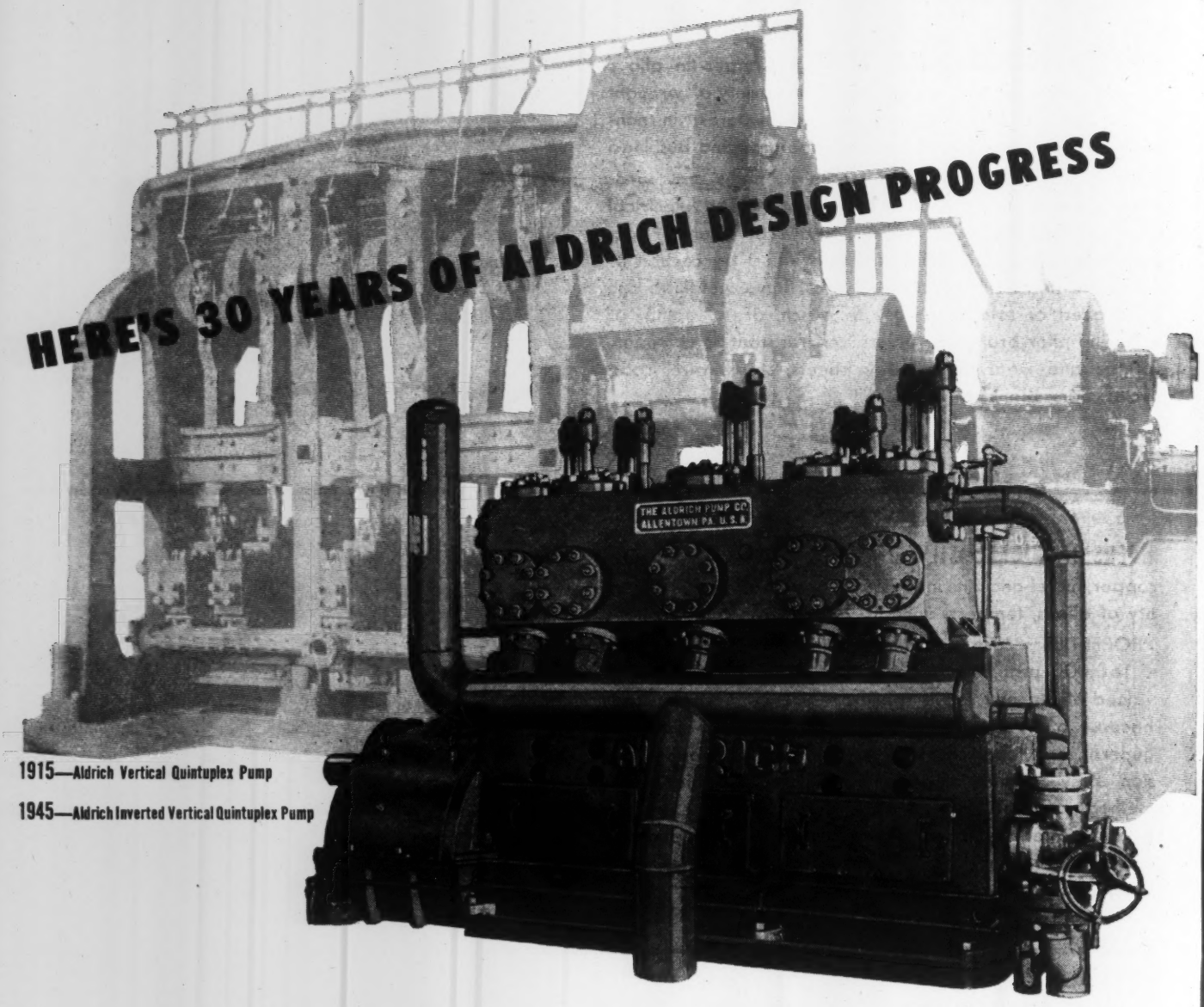


Typical Use: Electrical Instrument Contacts

Also special alloys of copper, zinc and tin for specific purposes

PHOSPHOR BRONZE
NICKEL SILVER
BERYLLIUM COPPER

HERE'S 30 YEARS OF ALDRICH DESIGN PROGRESS



1915—Aldrich Vertical Quintuplex Pump

1945—Aldrich Inverted Vertical Quintuplex Pump

• When placed in operation thirty years ago, the Aldrich Vertical Quintuplex Pump was the best that money could buy. Weighing 90,000 pounds and covering 145 square feet of floor space it was an engineering achievement built to operate under severe conditions for many years. With only routine maintenance and repairs, this pump *is still in operation.* Little wonder that Aldrich pumps have a reputation for sound design and construction.

Today, Aldrich Inverted Vertical Quintuplex Pumps are being specified for similar service. Through Aldrich modern design, a pump of comparable capacity would show that weight is reduced almost 73% to 25,000 pounds and floor space is reduced almost 83% to 25 square feet. These advantages reduce initial costs and operating expenses without sacrificing rugged, long-life construction.

Why not call on Aldrich engineers for assistance in the solution of your pumping problems? They have been doing this work for more than 40 years, and their specialized experience is available to you. Write to The Aldrich Pump Company, Allentown, Pa.

Representatives: Akron • Birmingham • Bolivar, N. Y. • Boston • Chicago • Cincinnati • Cleveland Denver • Detroit • Duluth • Houston • Jacksonville • Los Angeles • New York • Omaha Pittsburgh • Portland, Ore. • St. Louis • San Francisco • Seattle • Tulsa

ALDRICH . . . anticipates industry's pumping needs

CHAINS AND SPROCKETS FOR POWER TRANSMISSION AND THE MECHANICS OF MOVEMENT FOR MACHINERY AND EQUIPMENT OF AMERICAN INDUSTRY · AGRICULTURAL · AIR CONDITIONING · ALUMINUM ASSEMBLY · AUTOMOTIVE · AVIATION · BAKING · BOTTLING · BRICK BUILDING · BUSINESS MACHINES · CANNING · CEMENT · CERAMICS · CHEMICAL · COAL · CONCRETE · DAIRY · DIESEL · DRILLING · DRUG · ELECTRICAL ELECTRONICS · FISHERIES · FOOD · FOUNDRY · FURNITURE · GLASS · ICE · IRON LAUNDRY · LEATHER · LUMBER · MACHINE TOOLS · MARINE · MEAT · MILLING MINING · MOTION PICTURE · OIL · PACKAGING · PAINT · PAPER · PLASTICS · PORTABLE TOOLS · POWER GENERATION · PRINTING · PUBLISHING · QUARRY · RADIO · RAIL ROADS · REFRIGERATION · ROAD BUILDING · RUBBER · SALT · SAND · SHOEMAKING · STEEL · SUGAR · TEXTILE · WOODWORKING · WIRE

Everything..

your customer has the right to expect!

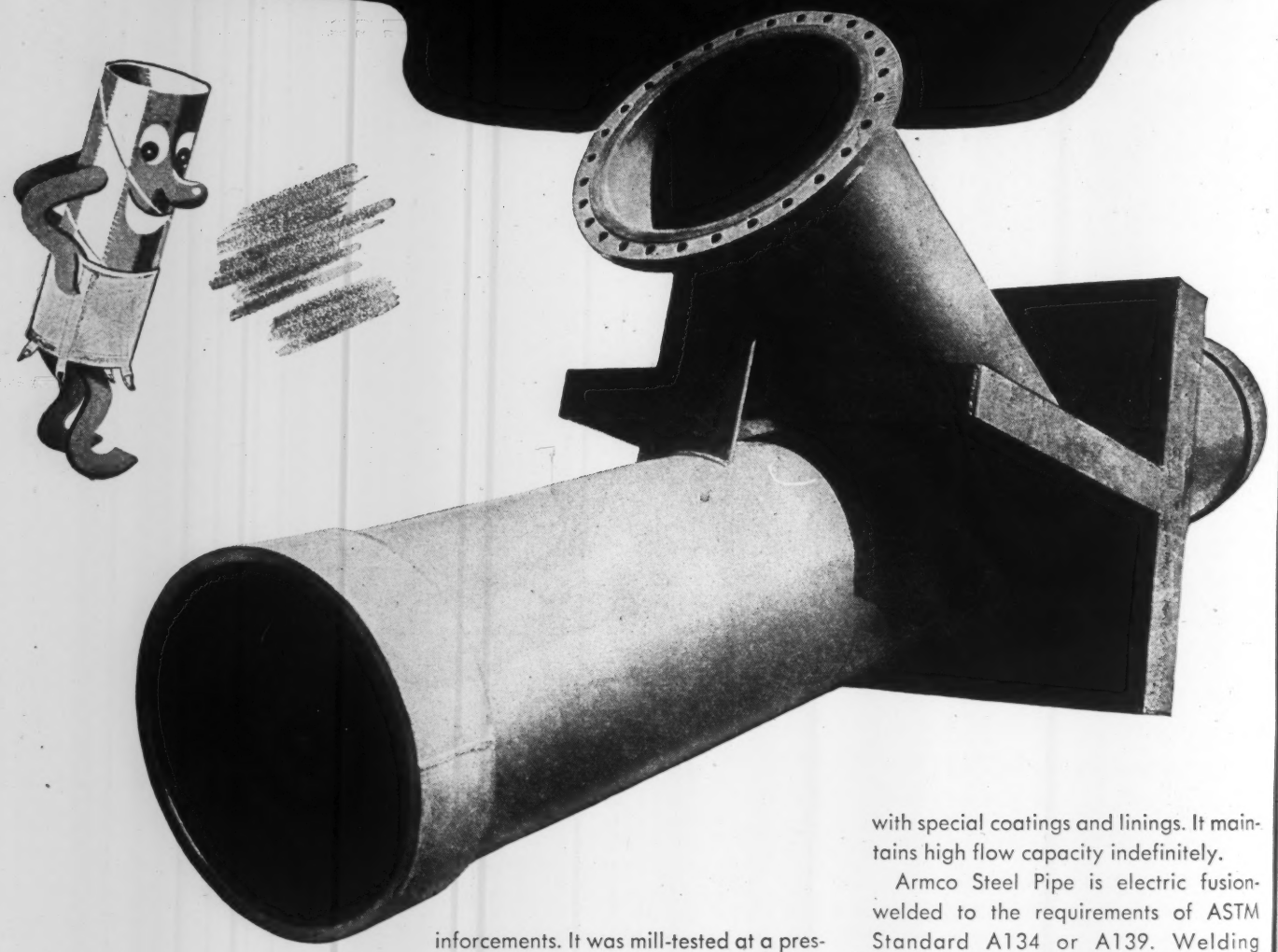
Chain...by LINK-BELT

There is a right Link-Belt Chain for every industrial use. The advice of LINK-BELT engineers is available to you. LINK-BELT COMPANY. Chicago 9, Indianapolis 6, Philadelphia 40, Atlanta, Dallas 1, Minneapolis 5, San Francisco 24, Toronto 8. Offices, factory branch stores and distributors in principal cities.

9028

This Pipe Wears A Girdle

FOR A 500 PSI. PRESSURE JOB!



"We want a special 30-inch lateral fitting that will take extreme water hammer and pressures up to 500 psi.!"

This was part of the blueprint for Armco Steel Pipe in a high pressure main for a large municipal water supply line. The fitting was no routine job; so Armco engineers "knuckled down." They designed a lateral with special welded reinforcements. It was mill-tested at a pressure of 500 psi. It didn't leak a drop or show any sign of distress.

EASY-TO-DESIGN LAYOUTS

Special prefabricated fittings like this make it easy to design plant piping and feeder lines to fit your requirements.

ARMCO Spiral Welded Steel Pipe has other advantages, too. Installation and maintenance costs are low, and there are fewer joints to service. Pipe is available with special coatings and linings. It maintains high flow capacity indefinitely.

Armco Steel Pipe is electric fusion-welded to the requirements of ASTM Standard A134 or A139. Welding Quality meets requirements of paragraph U-69 of the Unfired Pressure Vessel Code.

Diameters range from 6 to 36 inches, with wall thicknesses from 7/64 to ½ inch. For more information on Armco Steel Pipe just address Armco Drainage & Metal Products, Inc., 2951 Curtis Street, Middletown, Ohio.

ARMCO STEEL PIPE

When you're Planning VENTILATION..

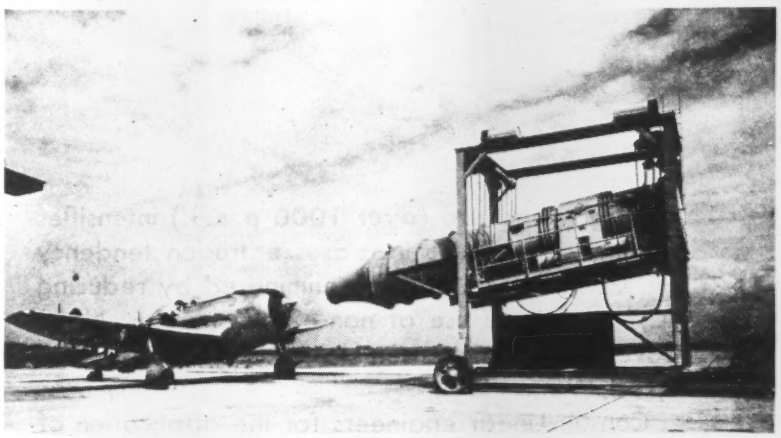
LOOK TO THE LEADER: LA-DEL

ORIGINATOR AND PIONEER MANUFACTURER OF AXIAL FLOW FANS

Whether your plans call for marine, aviation or automotive . . . industrial or domestic ventilation, it's certain you'll want the best equipment available. And in ventilation, the logical choice is La-Del. Here's why:

La-Del was the first to put the axial flow principle to practical application on many fronts . . . has continuously improved the design and construction of La-Del Axial Flow Fans to provide the utmost efficiency and economy of operation at the lowest possible cost. La-Del Axial Flow Fans have proved their dependability in rugged military service . . . soon they'll be available for civilian use.

And it's not too soon to begin planning your La-Del installation. Now is the time to discuss your ventilation problems with La-Del's experienced ventilation engineers. Write today, outlining your needs! Let La-Del show you how this modern ventilation system can solve your problems effectively and economically.



La-Del ability to handle the unusual and difficult jobs is evidenced by this huge blower furnished the N. A. C. A. Aircraft Engine Research Laboratory. It is a "life-saver" to test pilots and is capable of producing an air speed of 250 miles per hour. This La-Del fan permits test engines to be operated at maximum take-off power and eliminates the danger of take-offs with untried engines. Its output is 60,000 cfm at 45" ps . . . it is portable as shown . . . two stage, adjustable pitch, equipped with 500 HP motor and auxiliary blowers that ventilate the main motor through hollow vanes.

VICTORY BONDS—STILL THE BEST INVESTMENT YOU'LL EVER MAKE

LA-DEL FAN COMPANY

DIVISION OF

LA-DEL CONVEYOR AND MANUFACTURING CO.

NEW PHILADELPHIA, OHIO

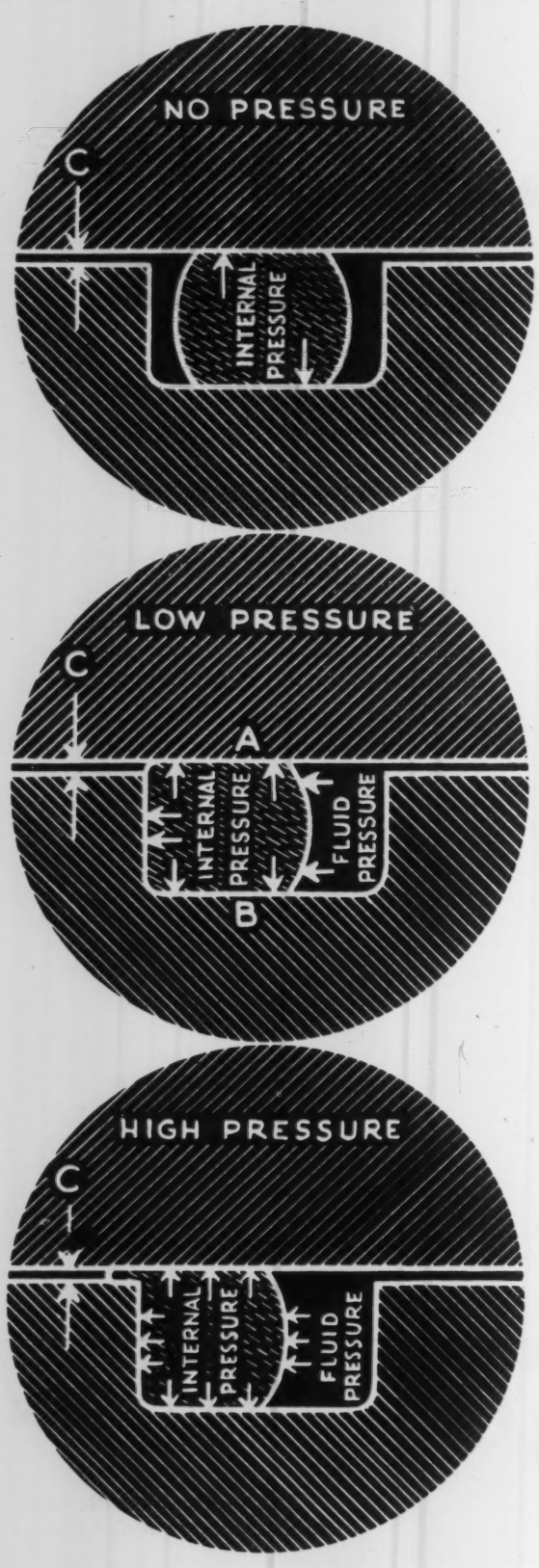
ENGINEERS OF LA-DEL AIR MOVEMENT

Originator and Pioneer Manufacturer of Axial Flow Fans

LINEAR O-Ring Packings . . .

Simple, Economical, Effective

"The Modern Hydraulic Seal"



O-Ring packings may be described simply as elastic rings with normally circular cross-sections. On account of their extreme simplicity, O-Rings require no adjustments and are readily replaceable. They occupy small space and seal in both directions. Made of a highly resilient synthetic rubber compound, Linear O-Ring packings seal effectively at low and high pressures. Their frictional drag is low. The action of these packings is shown in the accompanying diagrams.

◀ **At zero pressure,** seal is maintained by pressure of O-Ring on sealed surfaces resulting from cross-sectional squeeze. No extrusion through clearance "C."

◀ **Low pressure (1 to 1000 p. s. i.)** moves O-Ring to left side of groove, causing radial expansion of packing against sealed surfaces "A" and "B," proportional to pressure. Excessive clearance will permit extrusion at "C."

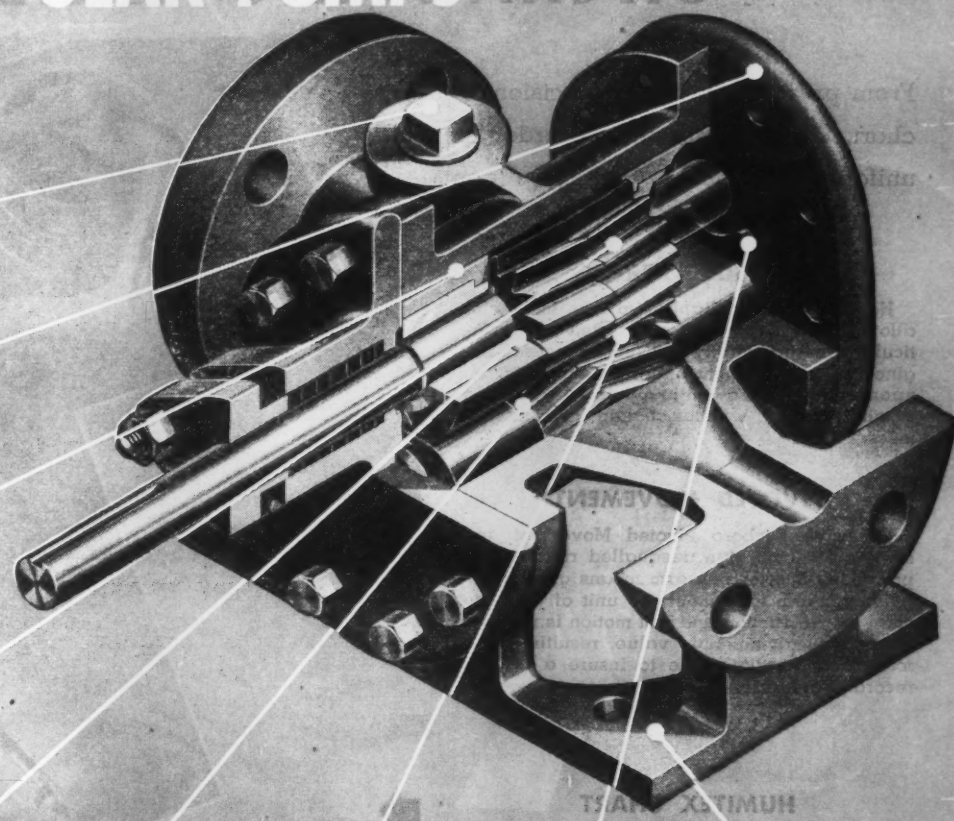
◀ **High pressure (over 1000 p. s. i.)** intensifies sealing action, also increases extrusion tendency at "C." Extrusion may be eliminated by reducing "C;" or by the use of non-extrusion rings. Note: Covered by Christensen United States patent No. 2,180,795.

Consult Linear engineers for the application of Linear O-Rings to your packing problems. Ask for sample rings.

LINEAR INCORPORATED

EXECUTIVE OFFICES & FACTORY
STATE ROAD & LEVICK STREET
PHILADELPHIA 35, PENNA.

FOR *Tough* PUMPING OPERATIONS SPECIFY SK GEAR PUMPS



Pipe Taps Permit By-Passing of Full Pump Capacity

No Dowel Pins

Straight Bore Housing Eliminates Bearing Overhang

Case-Hardened Gears Are Press-Fitted and Keyed to Prevent Lateral or Radial Motion

Rotor and Bearing Assembly Removable as a Unit

Relief Pockets Eliminate Liquid Trapping

Special High Pressure Tooth Angle Prevents Excessive Slippage

Pressure on Stuffing Box is Dissipated Through Channel in Cover Plates

Integrated Casting Provides Rigid Housing

Experience has proven smooth performance, high efficiency, low maintenance and long life of SK Gear Pumps in handling capacities up to 1000 gpm and pressure up to 3500 psi. For detailed information, write for Bulletin 17A.

SCHUTTE & KOERTING CO. *Manufacturing Engineers*

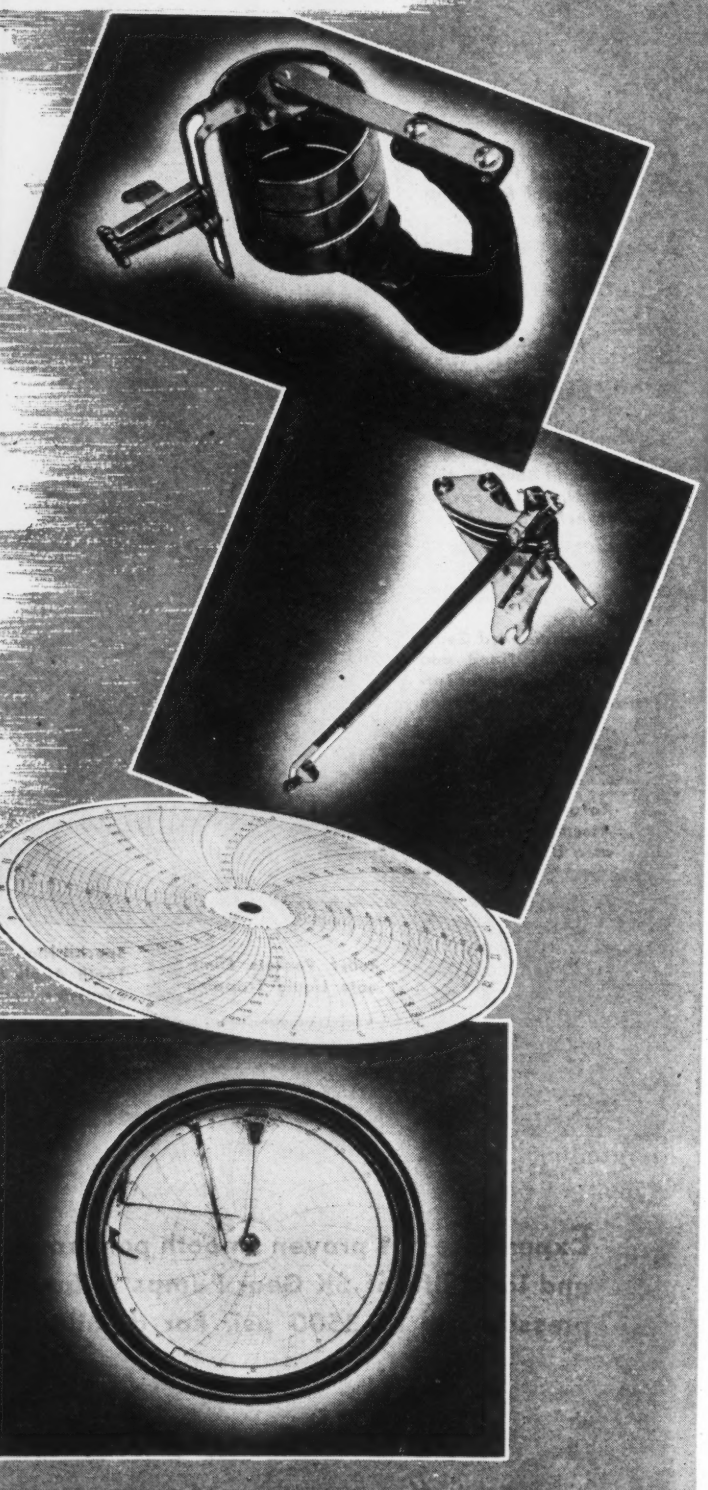
1166 THOMPSON STREET, PHILADELPHIA 22, PA.

JET APPARATUS • CONDENSERS AND VACUUM PUMPS • HEAT TRANSFER EQUIPMENT • VALVES • ROTAMETERS AND FLOW INDICATORS • GEAR PUMPS • STRAINERS • OIL BURNING EQUIPMENT • SPRAY NOZZLES AND ATOMIZERS • RADIAFIN TUBES

It all adds up to:

UNCHANGING CALIBRATION:

From pressure spring to precision-printed chart, Foxboro Pressure Recorder means uniform performance year-in, year-out.



PRESSURE SPRING

Helical, spiral or diaphragm type in special alloys . . . each one built and tested for a particular pressure service. Foxboro precision engineering makes them uniformly accurate, responsive, rugged, fatigue-free . . . withstand toughest service without change in characteristics.

PIVOTED MOVEMENT

Exclusive Foxboro Pivoted Movement and shorter pen arm give unequalled rigidity and precision. Shorter pen arm means greater angular pen-arm movement per unit of pressure change. All friction and lost motion is reduced to a practical minimum value, resulting in a *force-friction ratio* ample to insure a faithful record of pressure.

HUMITEX CHART

Literally precision-built. Made from paper specially produced to Foxboro specifications . . . printed in an air-conditioned press room from chromium-plated plates. Uniform beyond the possibilities of ordinary printing methods.

THE INSTRUMENT

Rugged, simple, engineered from start to finish with the care that has made Foxboro Instruments famous for *sustained accuracy*. Standard models for ranges up to 10,000 psi; higher ranges special. Multiple-pen models record up to 4 pressures on single chart. Write for Bulletin 22A containing full details. **The Foxboro Company, 182 Neponset Avenue, Foxboro, Massachusetts, U. S. A.** Also Montreal, Canada. Branches in principal cities.

FOXBORO REG. U. S. PAT. OFF. **PRESSURE RECORDERS**

Investigate THIS *New* SHAFT SEAL!

The **JOHN CRANE** Bellows Shaft Seal is giving excellent and trouble-free service on all types of shaft sealing applications, such as found on the following:

Turbine Pumps • Speed Reducers • Refrigeration Compressors • Rotary Pumps • Agitator Shafts • Centrifugal Pumps

This precision-built Shaft Seal automatically adjusts for washer wear and shaft end play. Eliminates stuffing box leakage, gland adjustment and shaft wear. Excellent for high speeds and high pressures.

The **JOHN CRANE** Bellows Shaft Seal can be furnished in various metals and synthetic rubber stocks in order to best suit different operating conditions. Made in two basic types: Type I (for limited diameter) and Type II (illustrated above) for limited length.

A Synthetic Rubber Bellows—tail seals on shaft. Head is flexible; adjusts automatically for washer wear or shaft end play.

B Protecting Ferrule—prevents flexible bellows from adhering to shaft; assures free movement.

C Sealing Washer—rotates with shaft; driven through metal parts; no torque on bellows.

D Sealing Faces—both carefully lapped at our factory to insure a perfect seal.

E Floating Seat—cushioned in synthetic rubber sealing ring, eliminating stress distortion of sealing faces.

Manufacturers and Design Engineers
Write for Bulletin!

Crane Packing Company • 1814 CUYLER AVENUE CHICAGO 13, ILLINOIS

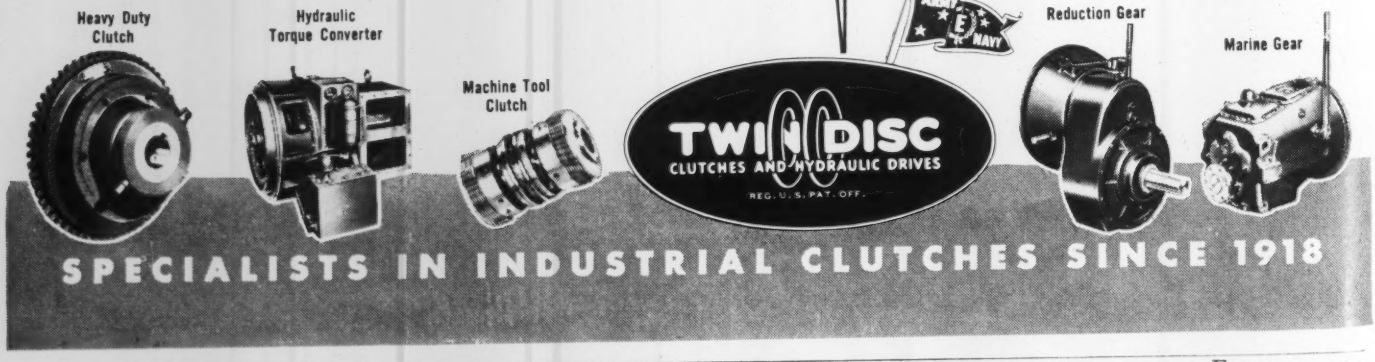
Baltimore • Boston • Buffalo • Cleveland • Dallas • Detroit • Houston • Los Angeles • New Orleans • New York • Philadelphia • Pittsburgh • San Francisco • St. Louis • Tulsa

Hangman's Helper...

The faded whorl of a fingerprint... the telltale texture of a wisp of hair . . . patiently probing the smallest detail until a noose of evidence tightens around the killer. That's the hangman's helper, the crime technician.

Industry, too, must have its patient probers. Twin Disc, for example, has for 27 years specialized in studying every detail of the transmission and control of power. This care to the smallest detail in the development, manufacture and application of Twin Disc Clutches and Hydraulic Drives is the reason why Twin Disc offers *proved power links* for almost every industrial application . . . is why, today, so many leading equipment builders rely on Twin Disc to provide the most efficient connecting link between driving and driven unit.

If the equipment you build poses a problem in power transmission or control, why not draw on the wide experience of Twin Disc engineers? Their recommendations as to "friction or hydraulic" will be impartial and unbiased . . . gladly given without obligation. TWIN DISC CLUTCH COMPANY, Racine, Wisconsin (Hydraulic Division, Rockford, Illinois).



One Name—ALL TYPES

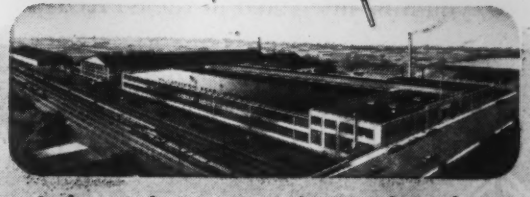
In fact, Phillie Gear was one of the true Pioneers in the design and manufacture of *Speed Reducers, for Industrial Purposes.*

For every conceivable type of Industrial Drive, there is a correct type of Philadelphia Speed Reducer—and by choosing Philadelphia Reducers, you not only secure *Quality Products,* but you place the responsibility for their construction and operation with *one manufacturer* (a point worthy of serious consideration).

ARMY E NAVY

Philadelphia GEAR WORKS INCORPORATED

ERIE AVE. AND G ST., PHILADELPHIA 34, PA. NEW YORK · PITTSBURGH · CHICAGO
IN CANADA: WILLIAM & J. G. GREEY LIMITED, TORONTO.



Industrial Gears and Speed Reducers
LimiTorque Valve Controls

THIS FLASHING LIGHT CAN HELP YOU

● The General Radio STROBOTAC, the entire production of which has been devoted to military needs, is now available for civilian use.

In research, design, production, testing, sales and maintenance the STROBOTAC provides an invaluable tool where the *exact* operation of high-speed equipment (operating up to as fast as *100,000 rpm*) has to be seen in s-l-o-w motion, even as slow as a fraction of an rpm.

Thousands of STROBOTACS are in use throughout industry . . . thousands more will be used in the coming years in hundreds of different plants where any rotating or reciprocating machinery is being manufactured or operated.

STROBOTAC production is gradually returning to a peacetime basis . . . STROBOTAC deliveries are improving daily.

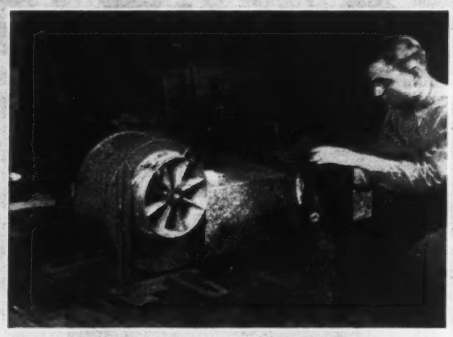
If you are interested in seeing the exact performance of any machine or part of any equipment while it is running at normal speed, you'll be interested in the STROBOTAC.

WRITE FOR BULLETIN 976 FOR COMPLETE DATA

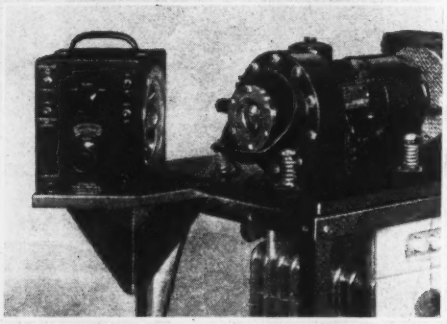
GENERAL RADIO COMPANY

Cambridge 39, Massachusetts

NEW YORK CHICAGO LOS ANGELES

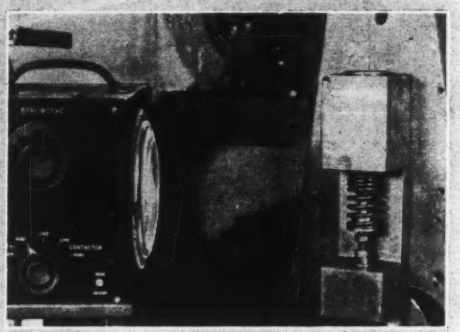


VENTILATION

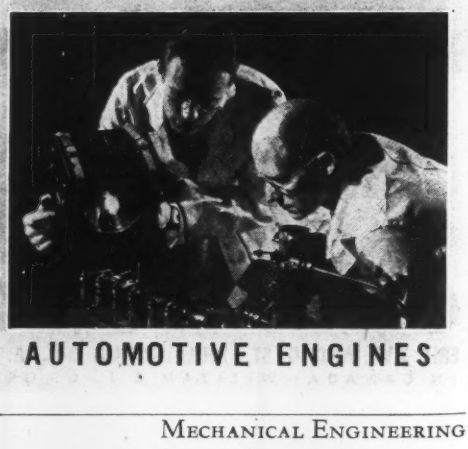


REFRIGERATION

SCREW MACHINES



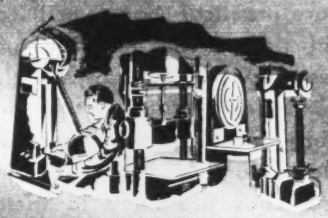
VALVE SPRINGS



AUTOMOTIVE ENGINES

IN Forgings YOU GET MAXIMUM METAL QUALITY Plus These Advantages

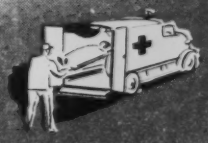
Valve Forging for High Pressure Service.



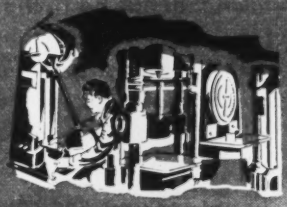
1. *High tensile and impact strength* obtained through controlled concentration of grain structure and fibre-like flow lines.

7. *Controlled concentration of fibre-like flow line structure* of metal at points of greatest shock and stress.

5. *Rapid assembly of complex parts by welding,* because forgings provide welding adaptability of widest range.



8. *A reduction of accidents to men and machines,* because forgings provide a greater margin of safety.



2. *A correctly proportioned combination of physical properties* to meet a specific service condition.

3. *Reduction of dead weight;* maximum strength and toughness in lighter sectional thicknesses.

4. *Reductions in cost of point of assembly* due to less time required to machine and finish, and fewer rejects.

Forging metals in closed impression dies develops maximum metal quality. A product fortified with the metal quality found in forgings outperforms other products. A recheck of every stressed part whether of simple or complex design, against the seven advantages that forgings offer may reveal the possibility of further strengthening a part or a product to give longer service life; to lessen weight; to reduce the cost of machining and finishing; to speed up assembly. Consult a forging engineer connected with your source of supply about the wide range of combinations of quality advantages that are available in forgings, and how you can obtain metal quality in the exact degree required for a specific condition. Forging techniques required to forge so-called "impossible-to-forge-designs" are now available for the production of peacetime forgings.

DROP FORGING ASSOCIATION

605 HANNA BUILDING • CLEVELAND 15, OHIO

DROP FORGING ASSOCIATION
605 Hanna Building • Cleveland 15, Ohio

☐ Booklet on "Metal Quality—Hot Working Improves Properties of Metal."

☐ "Drop Forging Topics," issued ten times a year.

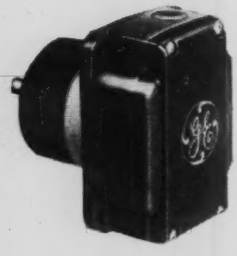
Name ..... Position .....

Company .....

Address ..... City ..... State .....

Designer's

FASTER STOPS WITHOUT BRAKES



G-E plugging switch for flange mounting—for built-in applications

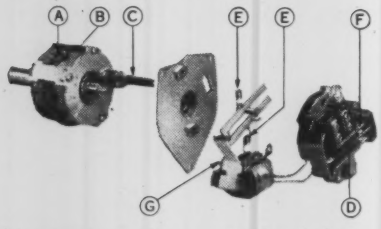
G-E plugging switch for surface mounting—for general-purpose applications

New G-E PLUGGING SWITCH

reduces lost machine time by bringing motors to rest quickly between operations

Now it is simpler and more practical than ever before to equip your machines with time-saving, maintenance-saving plugging control. These new G-E plugging switches have been designed to take full advantage of the small size and high external energy of G-E alnico magnets. Available now for both flange and surface mounting, these oiltight, dustproof switches are easy to install. Their smooth-contoured, die-cast enclosures give a pleasing appearance that will "go well" with your modern machines.

How this *New* switch operates



Eddy currents are induced into a driven member (A) which rotates in the magnetic field produced by the alnico magnets (B). The resulting reaction turns the magnet assembly through its limited arc, and the contacts are operated by the Textolite arm (C) which connects the assembly to the movable contact strip (D). Springs (E) tend to hold the contacts (F) in the normal position so that, as the speed (and magnetic force) decrease, a point is reached where the springs take over and open the contacts. Lock-out device (G) holds contacts in OFF position until solenoid is energized.

Two spring sizes are available, for speed ranges of 40 to 140 rpm and 140 to 750 rpm. The switch's speed limit is 1800 rpm, but higher-speed applications can easily be made by gearing or belting down to the switch shaft.

BUILT FOR LONG LIFE

With a contact-making mechanism that has no frictional parts or clutches, G-E plugging switches are inherently long lived. Use of a spring-bronze contact strip gives a wiping action that keeps the switch contacts clean and assures dependable operation with little maintenance.

Safety to operating personnel is also an important feature of these switches. A simple lockout device can be provided which serves to keep contacts in the OFF position until the motor is energized. This prevents accidental starts in case the motor is turned over by hand in making a machine setup.

Adjustment of contact operating speed is made quickly and easily with a screw driver.

For complete details on these little "production boosters", check "plugging switch" data on the coupon to the right.

Keep on buying BONDS—and *keep all you buy*

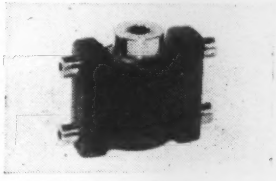
GENERAL ELECTRIC

Digest

TIMELY HIGHLIGHTS ON G-E PRODUCTS

G-E mycalex

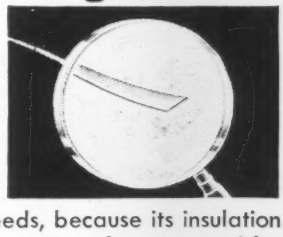
...insulation extraordinary



This outstanding inorganic insulation material can be molded with or without metal inserts to precise, permanent dimensions. For electronic, power, and appliance equipment, where high dielectric strength, heat and arc resistance, or low dielectric power losses are essential requirements, ask for G-E mycalex.

Thinnest

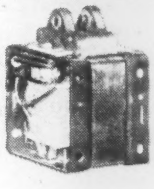
...rectangular magnet wire



Did you know that rectangular Formex* magnet wire is now available in widths down to 0.085 inch and in thicknesses down to 0.004 inch. Formex magnet wire permits higher coil winding speeds, because its insulation is not easily damaged. There is, therefore, no need for fibrous coatings. Varnish treatment, if needed, is easier. For details, check Bulletin GEA-3911 on coupon.

Solenoids

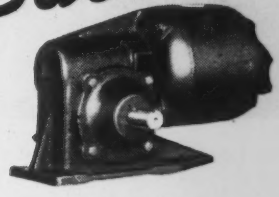
...for reliable push and pull



If you have a job where a straight-line motion (push, pull, or reciprocating) is required, try G-E solenoids for steady, accurate performance. Maximum voltage for all types is 600; 60 to 25 cycles, and d-c. Maximum stroke range is from ¾ inch to 3 inches. Check "solenoid data" on coupon for more details.

*Trade-mark reg. U.S. Pat. Off.

Power Savers



that need less space

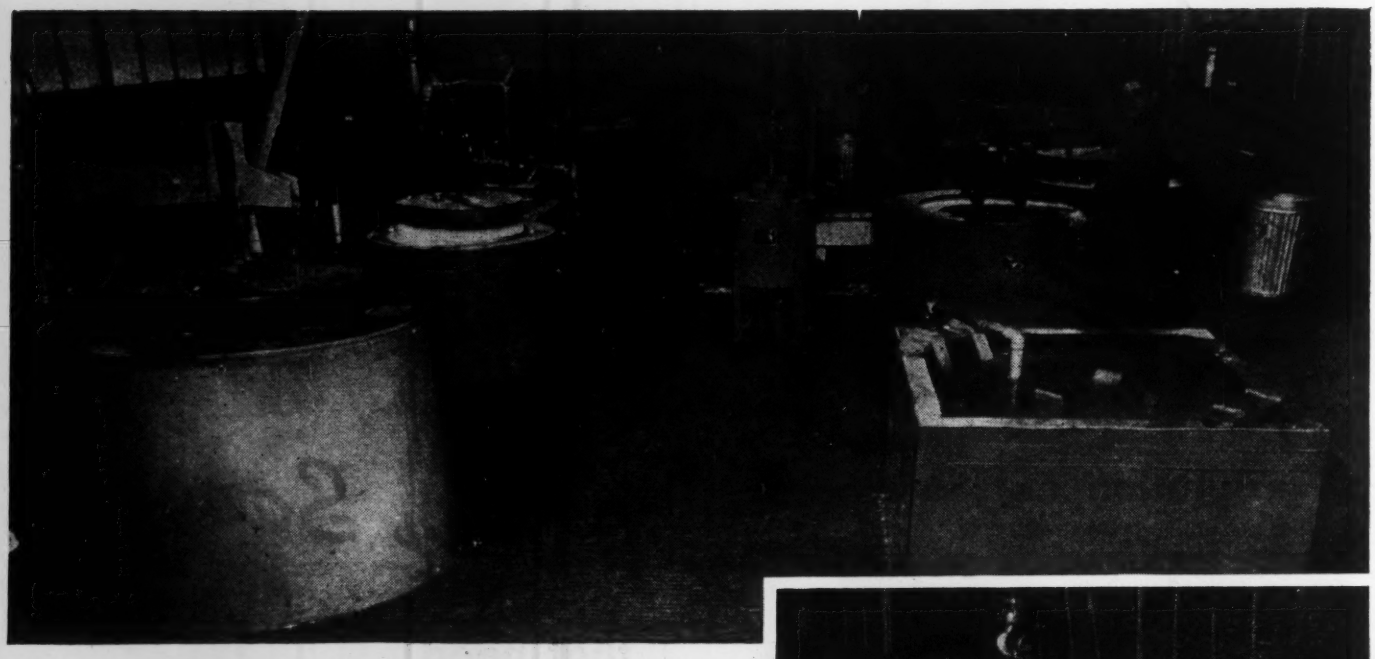
IF your machine requires a small low-speed motor, you'll like the two big advantages of G-E fractional-horsepower gear-motors. First, they operate at a higher efficiency than any other low-speed drive of comparable cost. This means a substantial power saving for your customers. Second, the planetary-gear system used permits a compact package of motor and speed-reducer that requires little more space than motor alone. Designwise, this gives you a better-looking machine. G-E gear-motors require less maintenance and are easy to install.

The G-E line of fractional-horsepower gear-motors covers a range of standard ratings from ⅛ to ¾ hp, in polyphase, single-phase, and d-c types. You also have a choice of either the concentric-shaft, planetary-gear type (for speeds between 520 and 13.5 rpm) and the right-angle shaft, single-worm or planetary-worm type (for speeds between 197 and 5.7 rpm). For more details, ask for Bulletin GEA-3981.

GENERAL ELECTRIC COMPANY
Apparatus Department, Section 668-46, Schenectady 5, N. Y.
Please send me the following bulletins:
GEA-3911—Formex magnet wire
GEA-3981—Fractional-hp gear-motors
More data on: Plugging switches .....
G-E mycalex .....
Solenoids .....
See your copy of Sweet's 1945 File for product designers—it contains 102 pages listing G-E equipment

Name .....
Company .....
Street .....
City ..... **State** .....

8579



General view of heat-treat department, Tube-Reducing Corp., Wallington, N. J. A Rockrite die, used in cold-reduction of the company's "Rockrite" tubing, is being lowered into one of the four big Vapocarb-Hump hardening furnaces.

Heavy Production of

DIES AND MANDRELS

Uses VAPOCARB-HUMP Hardening

Heat-treatment of tube-reducing dies and mandrels is in many ways a production job, rather than a series of tool-room problems, in Tube-Reducing Corp.'s plant. Jigs and fixtures standardize the placing and handling of the large numbers of tools in the furnaces and quench. Records of performance are guides in maintaining standard procedures, and, wherever possible, all controls are automatic.

A central factor in securing uniformity plus automatic control is use of the Vapocarb-Hump Method for hardening. Four large Vapocarb-Hump furnaces assure the same protective atmosphere for all dies and mandrels, so that pitting and scaling are equally prevented. The Micromax recording controllers, each with its two sensitive, carefully-placed thermocouples, show temperatures of both dies and furnace walls and enable heating to be held to any desired rate or soak point. Micromax records are easy to inter-compare, and results obtained in one furnace can be duplicated in any other.

Our compact, well-illustrated Catalog T-621 gives a complete description of the Vapocarb-Hump equipment and the results it is helping users secure. A copy is free on request.

Close-up of operation shown at top of page; Rockrite die, made of SAE52100 chromium steel, is cradled in special furnace fixture; and will be lowered into Vapocarb-Hump furnace for automatically-controlled heating, at specified rate, in Vapocarb protective atmosphere. Quenched on a falling temperature, it will have a Rockwell "C" hardness of 60 to 62, with uniformly smooth surface.

LEEDS & NORTHRUP COMPANY, 4963 STENTON AVE., PHILA. 44, PA.

LEEDS & NORTHRUP

MEASURING INSTRUMENTS · TELEMETERS · AUTOMATIC CONTROLS · HEAT-TREATING FURNACES

Jrl Ad T-621(33)

VICTORY OVER VIBRATION

IN COMMUNICATIONS

AIR — LAND — SEA

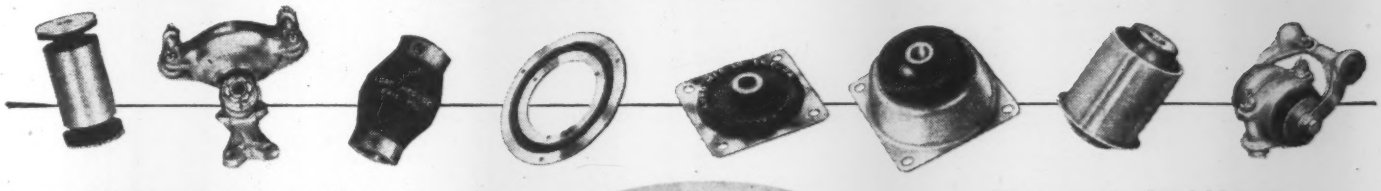
Radio, electronic and radar equipment is necessarily delicate in construction and necessarily precise in its functioning. The enormous recent advances, first made on paper, when translated into practice have almost invariably run into one major difficulty . . . vibrational interference.

So, Lord, pioneer and leader in subduing the harmful forces of vibration, has been called upon for a wide range of applications in this field. Where possible, outside vibration forces have been isolated at their source; vibration of component parts has been controlled; and delicate parts and instruments have been protected from outside interference by isolation.

Lord engineers, the most experienced in the field of vibration, have access to the greatest file of experimental data and case studies of practical experience in existence, and they have the largest assortment of mountings, all of exclusive Shear Type Bonded Rubber and every one engineered for the specific conditions it has to meet.

The safety of passengers in the air, on land and sea; the pleasure of large audiences; the enjoyment of radio and television at home; all depend on the efficiency of communication systems, an efficiency which has been accomplished and continues to be promoted by constant consultation with Lord, HQVC (Headquarters for Vibration Control).

LORD
SHEAR TYPE
Bonded Rubber
MOUNTINGS



IT TAKES BONDED RUBBER *In Shear* TO ABSORB VIBRATION

LORD MANUFACTURING COMPANY
ERIE, PENNSYLVANIA

SALES REPRESENTATIVES
NEW YORK - - 280 MADISON AVE.
CHICAGO - - 520 N. MICHIGAN AVE.
DETROIT - - 7310 WOODWARD AVE.
BURBANK, CAL. - 245 E. OLIVE AVE.
CANADIAN REPRESENTATIVES
RAILWAY & POWER ENGINEERING CORP., LTD.
TORONTO, CANADA

Originators of Shear Type Bonded Rubber Mountings

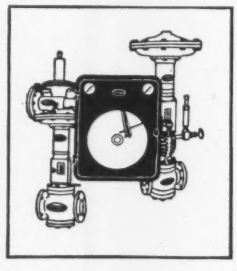
Every genuine Lord Mounting carries the name "LORD" embossed in the rubber or in raised letters on the forgings.

IF YOU COULD PEEK THROUGH THIS KEYHOLE

Behind every Mason-Neilan product is a background of successful manufacturing dating back to 1882. Throughout these 63 years, it has been intimately associated with petro-chemical and other process industries . . . developing and manufacturing the highest quality regulators, instruments, and controls . . . solving their most intricate problems.

To earn and maintain its enviable reputation Mason-Neilan maintains research, application engineering and field engineer departments unexcelled in the industry. Behind these doors, various groups constantly work together . . . improving products . . . developing new controls and equipment . . . keeping abreast of new processes and anticipating requirements. Naturally these activities cost money and are reflected in our selling price to you. Thus *"Masoneilan Equipment is built up to the job . . . not down to a price"* takes on a *real* meaning. A meaning which assures dependability and over-all economy of operation of all Masoneilan products.

We suggest that you make use of Mason-Neilan's facilities whenever you have regulator, control valve, liquid level control or instrument requirements. Our engineers are at your service.



Masoneilan Equipment . . . Built up to the job, not down to a price

MASONEILAN

MASON-NEILAN REGULATOR CO.

1208 ADAMS STREET, BOSTON 24, MASS., U. S. A.

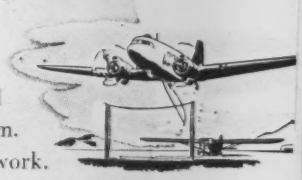
New York Philadelphia Pittsburgh Cleveland Chicago Tulsa Atlanta
St. Louis Houston Los Angeles San Francisco Mason Regulator Co. of Canada, Ltd., Montreal, Canada

In Springs—

it's the X-Dimension that gives a Glider and You a Lift

Ever hear of the X-Dimension of a Spring? Probably not. But, sure as you're born it's there, in every spring. Take, for instance, the intriguing what-is-it pictured below. It's a glider release spring, an assembly which holds the pick-up rope until the parent plane hitches on—then let's go at a precise jerk on the towline.

If Hunter had only manufactured and delivered dependable glider release springs on time and in needed quantities, its job would have been satisfactory. But Hunter invented the device for All American Aviation, Inc., and assigned the patents to them. That's the X-Dimension at work.



It's also at work in such pioneering efforts in spring manufacture as control gaging and statistical methods in quality control. It's your guarantee of good springs, your insurance against failures and customer complaints. It's *more* than you bargained for—in springs.

HUNTER
Science in Springs

HUNTER PRESSED STEEL COMPANY
Lansdale, Pennsylvania
SPRINGS • METAL STAMPINGS • WIRE FORMS
MECHANICAL AND ELECTRICAL ASSEMBLIES

MEMO TO PURCHASING MEN—

• Next time your engineers hand you a tough spring procurement job, let Hunter help you get your money's worth.

THE ALCO FUEL

for high efficiency and economy

An Extended-Surface Heat Exchanger

Reconversion to peace is under way, and this new ALCO standardized product is a head start to conversion for industrial oil-burner installations.

The heavier-grade and less-expensive oils require preheating for proper atomization and efficient combustion.

Now offered for IMMEDIATE SHIPMENT FROM STOCK, this Alco Fuel Oil Heater offers these important features:

1. HIGH HEAT TRANSFER DUE TO:

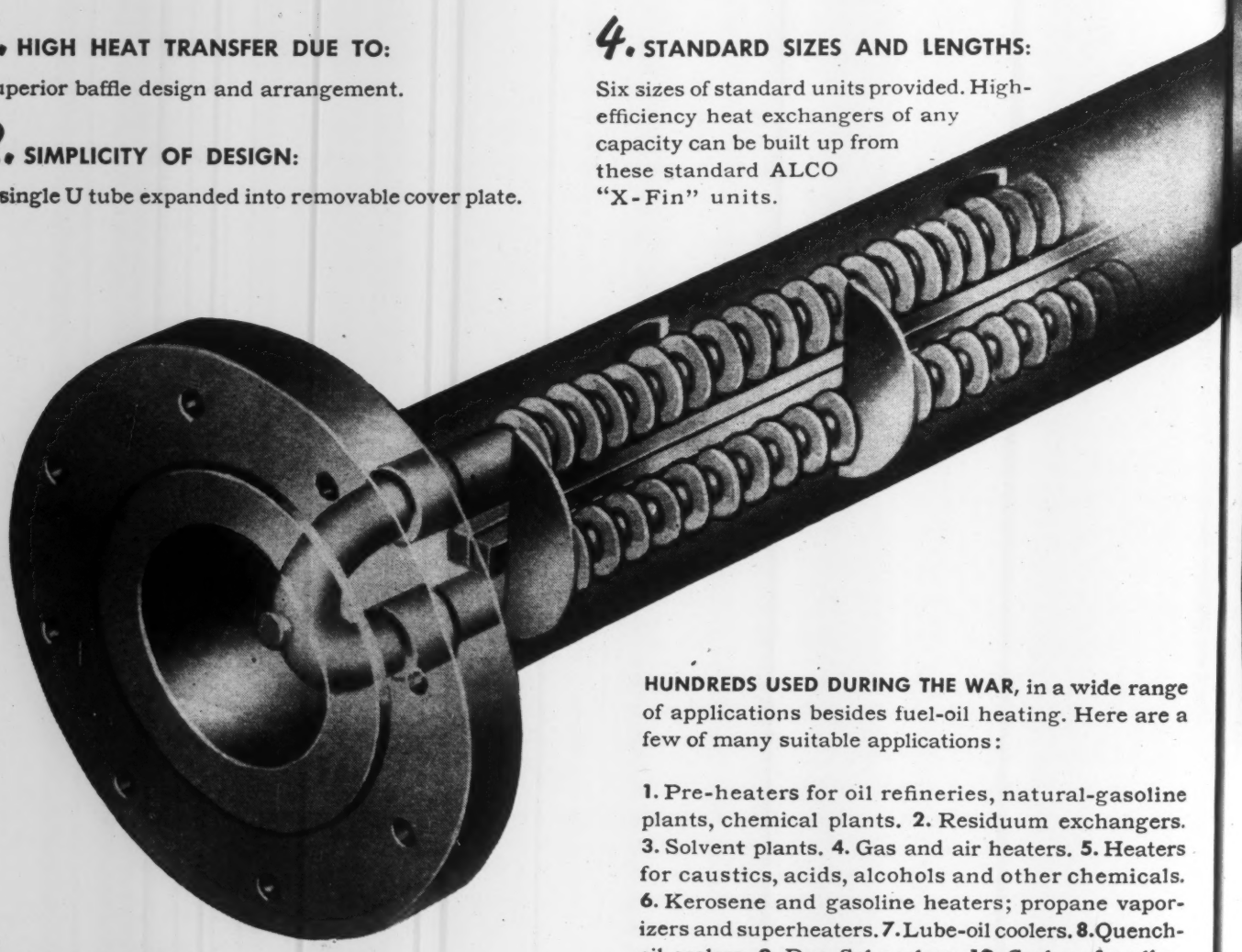
Superior baffle design and arrangement.

2. SIMPLICITY OF DESIGN:

A single U tube expanded into removable cover plate.

4. STANDARD SIZES AND LENGTHS:

Six sizes of standard units provided. High-efficiency heat exchangers of any capacity can be built up from these standard ALCO "X-Fin" units.



3. EASY TO CLEAN:

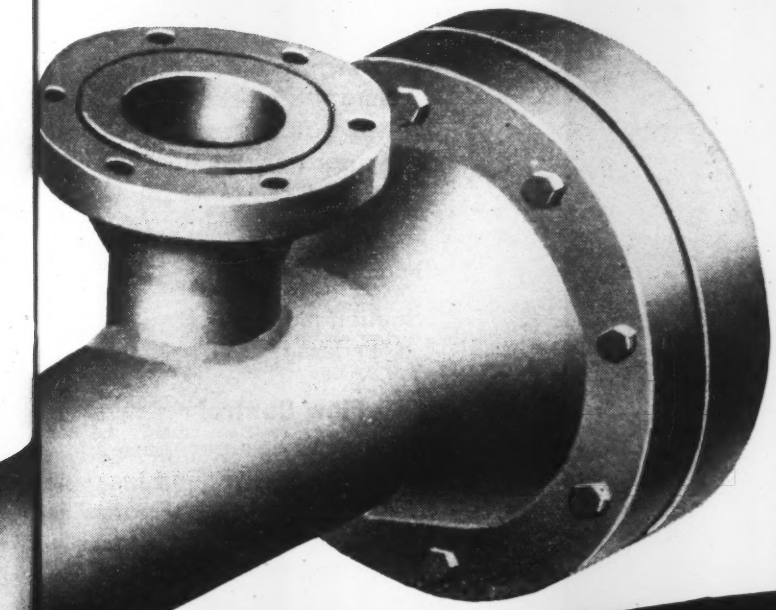
Baffle assembly easily separable from heat-transfer element.

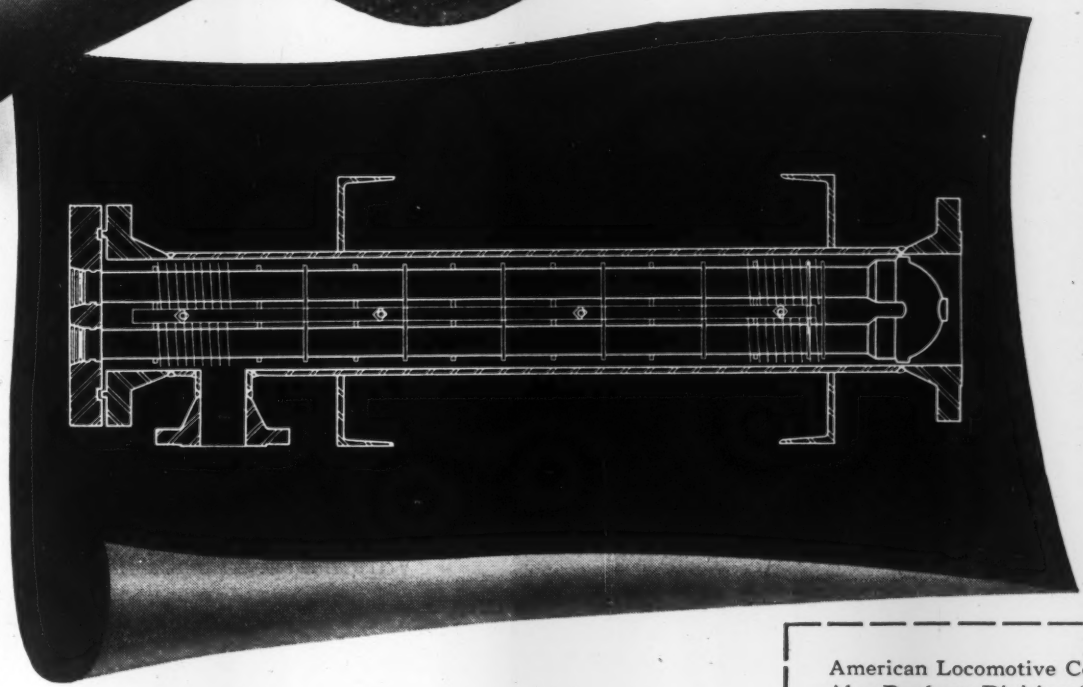
HUNDREDS USED DURING THE WAR, in a wide range of applications besides fuel-oil heating. Here are a few of many suitable applications:

1. Pre-heaters for oil refineries, natural-gasoline plants, chemical plants. 2. Residuum exchangers. 3. Solvent plants. 4. Gas and air heaters. 5. Heaters for caustics, acids, alcohols and other chemicals. 6. Kerosene and gasoline heaters; propane vaporizers and superheaters. 7. Lube-oil coolers. 8. Quench-oil coolers. 9. Duo-Sol coolers. 10. Coolers for alkylation plants. 11. Gasoline and kerosene coolers. 12. Coolers for absorption processes. 13. Gas and air coolers. 14. Compressed-air aftercoolers.

OIL HEATER

in space...weight...cost...and maintenance





OTHER ALCO PRODUCTS:

Oil-Tank Suction Heaters · Feed-Water Heaters

Evaporators · Reboilers

Air-Cooled Heat Exchangers · Lube-Oil Coolers

Jacket Water Coolers · Vapor Heat Exchangers

Vapor Condensers · Waste-Heat Boilers

Prefabricated Piping · Electric-Welded Steel Pipe

Pressure Vessels · Pipe-Line Filters

Weldments

Write for New Bulletin

A copy of the new ALCO Bulletin, No. 1036, describing and illustrating this new line of ALCO products will be sent you promptly, on request. Write for it today.

American Locomotive

Alco

ALCO PRODUCTS DIVISION

30 Church Street, New York 8, N. Y. • Dunkirk, N. Y.

American Locomotive Company
Alco Products Division (11)
30 Church Street, New York 8, N. Y.

Please send me your new bulletin #1036, about the Alco Fuel Oil Heater.

Name.....

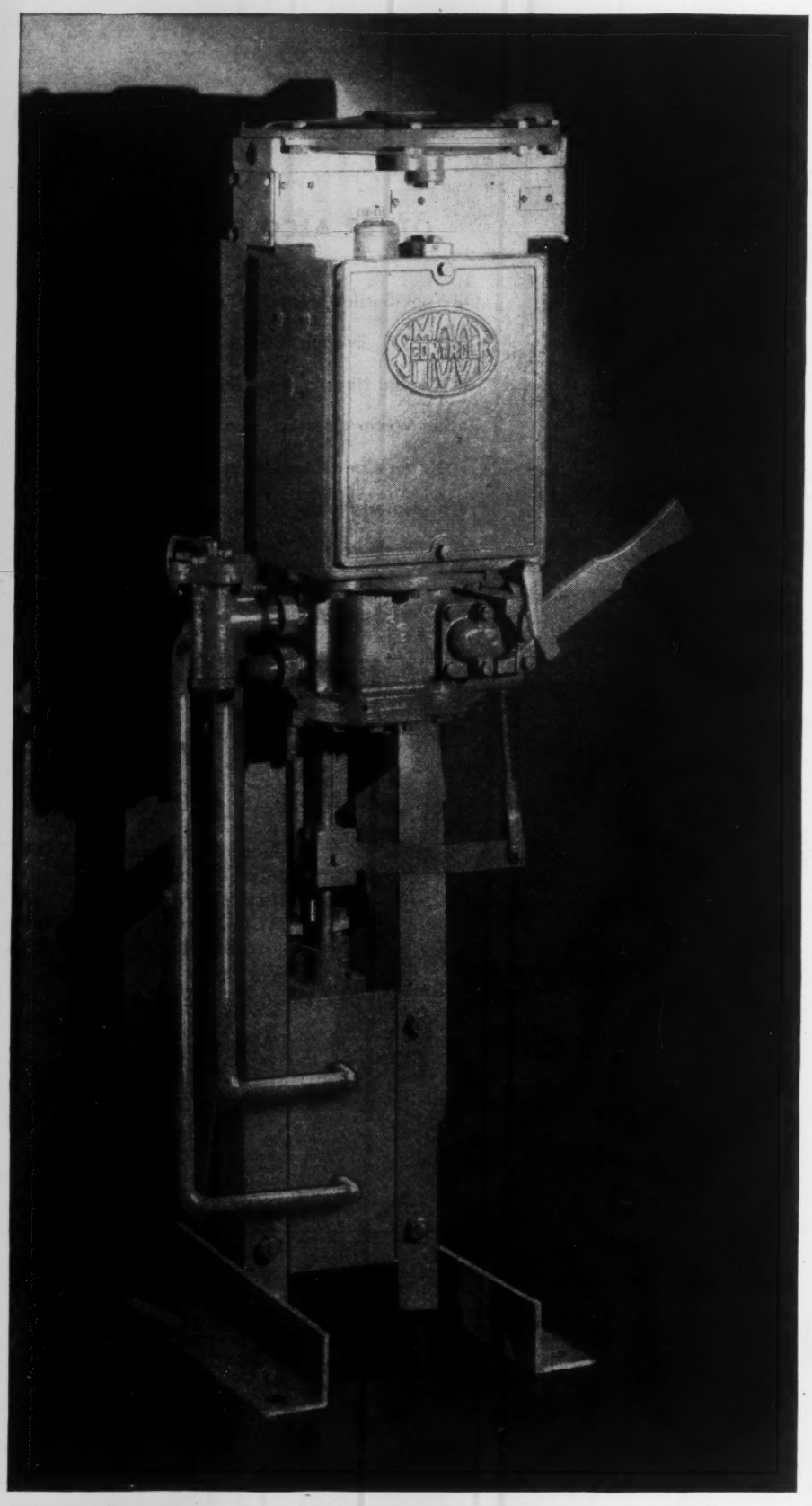
Title.....

Company.....

Street.....

City and State.....

The Trend is to...



REPUBLIC REGULATOR APPLICATIONS

Pressure Control

Steam pressure control
Boiler furnace draft
Primary air pressure
Feed water pressure
Evaporator pressure
Process steam pressure
Blast air pressure
Exhauster suction
Fuel gas pressure
Suction main pressure
Excess pressure

Flow Control

Water flow to desuperheaters
Water flow to condensers
Oil flow to boilers and furnaces
Gas flow to boilers and furnaces
Air flow to gas producers
Pump bypass

Level Control

Hot well levels
Surge tank levels
Storage tank levels
Evaporator levels
Boiler water levels

Speed Control

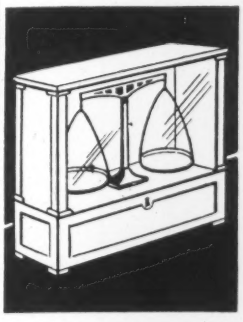
Stoker and fuel feeder speeds
Pulverizer speed
Pump speed
Fan speed
Steam turbine speed
Steam engine speed
Variable speed motors
Variable speed transmissions

View of a Republic hydraulic type regulator for controlling boiler air flow, mounted on stand with power cylinder.

REPUBLIC
INSTRUMENTS
AND CONTROLS

REPUBLIC Regulators

Because They Meet These Four Essentials of Good Regulation



Republic Regulators can be made sensitive to changes of less than 0.002 of an inch of water.

SENSITIVITY

The amount of change that is required in the quantity being controlled to effect the regulator is the measure of its sensitivity. For close, accurate regulation, a regulator must be sensitive. It must respond immediately to the slightest deviation from the predetermined setting or the controlled quantity may vary far beyond the permissible limits.

Republic Regulators will meet any speed requirement up to one full stroke in 2 seconds.

SPEED

The speed at which a regulator operates is an important factor in any control system. Any time lag between the variations in the controlled quantity and the operation of the control device to correct this variation, will produce an unnecessary error in regulation. A regulator, therefore, must be fast enough to follow the fastest load fluctuation.

Republic power cylinders are available to meet the specific power requirements of any particular installation.

POWER

A regulator must have sufficient power to not only operate the valve or other control device, but also to overcome any accidental friction or sticking that may occur in any part of the system. Insufficient power will cause failure in operation. It is for this reason that regulators are made with different size power cylinders, the smaller sizes being used for small valves and the larger sizes for the larger dampers and louvers.

The Republic stabilizer will stabilize against any time lag in the operation of the equipment being controlled.

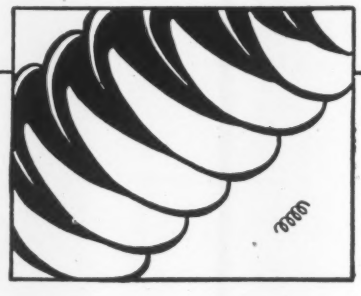
STABILITY

Stability refers to the ability of a regulator to maintain its balanced position or to return immediately to a balanced position if the controlled quantity is disturbed. There is always an interval between the time the valve or other control device is moved and the time the controlled quantity changes in response to this movement. Unless a regulator is stabilized it will tend to "hunt" or overtravel causing unnecessary variations.

Write for Data Book No. S-13

Republic Flow Meters Co.

2222 Diversey Parkway • Chicago 47, Illinois



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NO JOB TOO SMALL!

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Every problem that comes to us undergoes a thorough checkup. We like to start at the beginning, and check and double-check every factor of design and requirement. Then, we establish the formula for the steel (for your particular spring); make it in our own open hearths; draw, form, temper and test it in our own mills. No factor is overlooked in our efforts to serve you.

Send for a copy of our free book "Springs and Wire Forms." It gives data relating to spring performance, including formulae, tables and other technical information needed in proper spring selection. Address Wickwire Spencer Steel Company, New Bond Street, Worcester 6, Massachusetts.

It takes an entire coil of wire to form the largest spring we make—such springs are used on the huge overhead doors in aircraft hangars. This same coil of wire will produce 8,000,000 of the smallest springs we make—tiny springs that go into delicate recording instruments.

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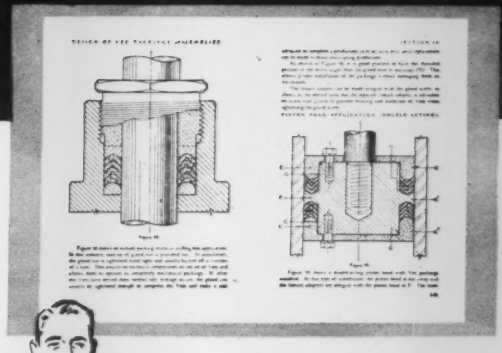

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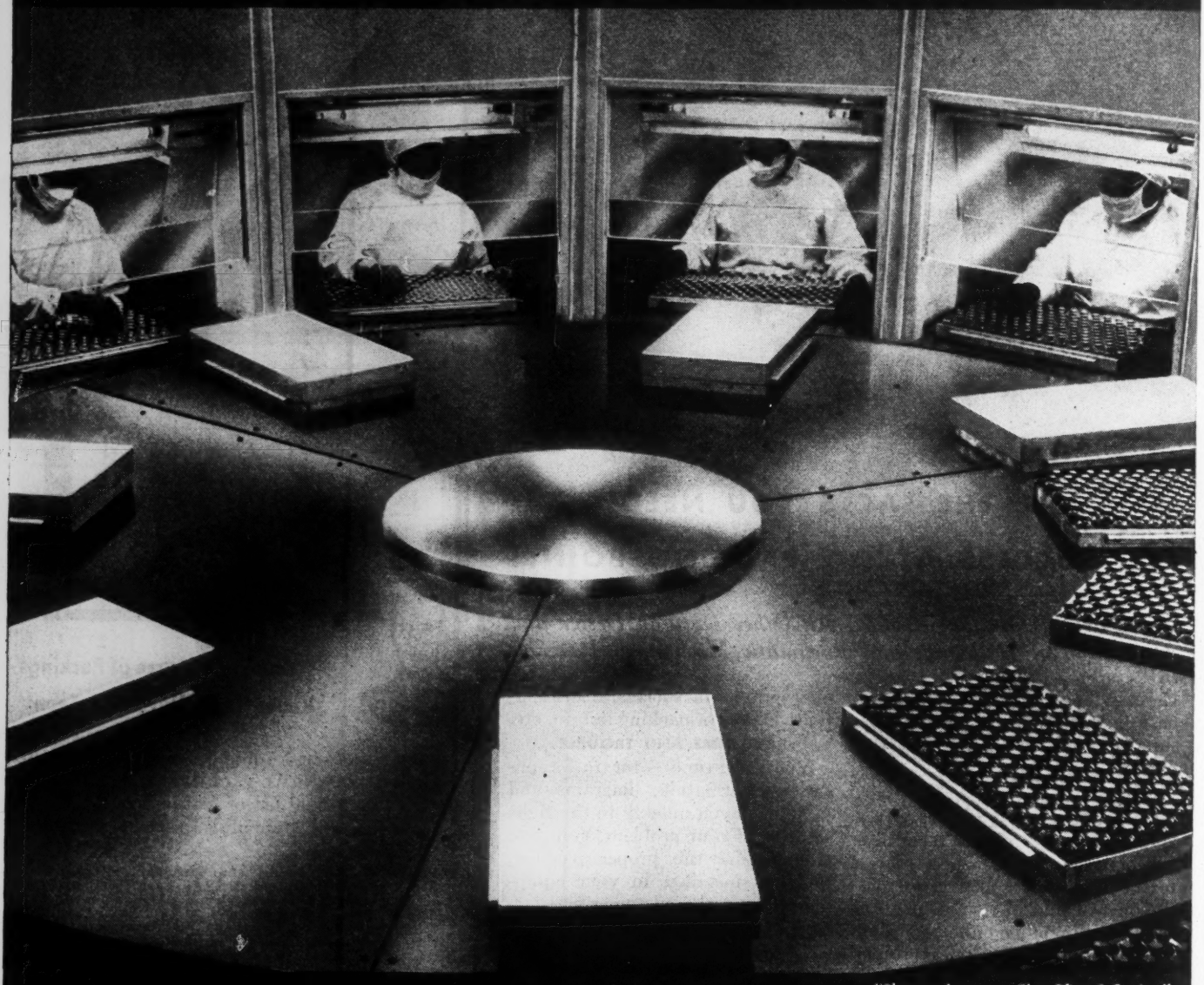

"Photograph courtesy Chas. Pfizer & Co., Inc."

Packaging the miracle drug... penicillin...calls for completely sterile conditions. Here the table must be the very acme of aseptic cleanliness... easy to clean and keep clean. Hence, it's chromium-Nickel stainless steel.

• • •

International Nickel are miners, smelters and refiners of Nickel, an important ingredient of the stainless steels, but do not produce stainless steels. If interested, please communicate with your established sources of supply for stainless steels.

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PREFABRICATION with Tube-Turn welding fittings can effect important savings. Particularly is this true where piping must fit into tight space—up against a wall or ceiling, into narrow pits under floors, or in a ship, to cite only a few examples. It takes elbow room to tighten bolts and screw flanges, but a prefabricated section can be fitted into tight spots easily—and economically.

Such sections are as strong as though originally forged in one piece. Each elbow, tee and flange is welded with a joint actually stronger than the pipe itself. Tube-Turn welding fittings contribute to the best possible piping job, whether the problem be new construction, replacement, or assembly into a manufactured product.

For complete information on the superiority of Tube Turns' exclusive manufacturing methods and data on successful installations in many industries, write for Catalog 111.

Selected Tube Turns distributors in every principal city are ready to serve you from their complete stocks.

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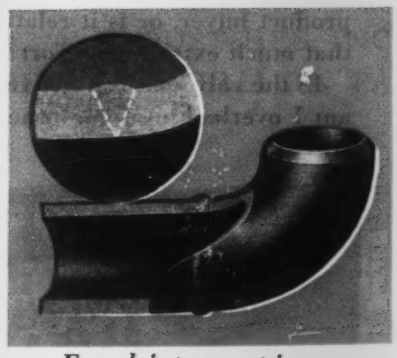
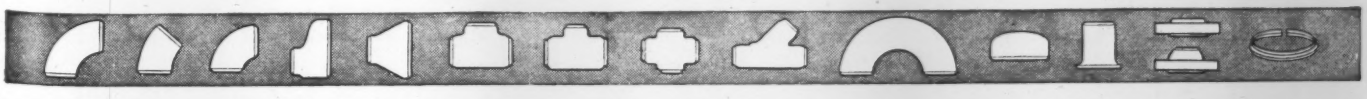
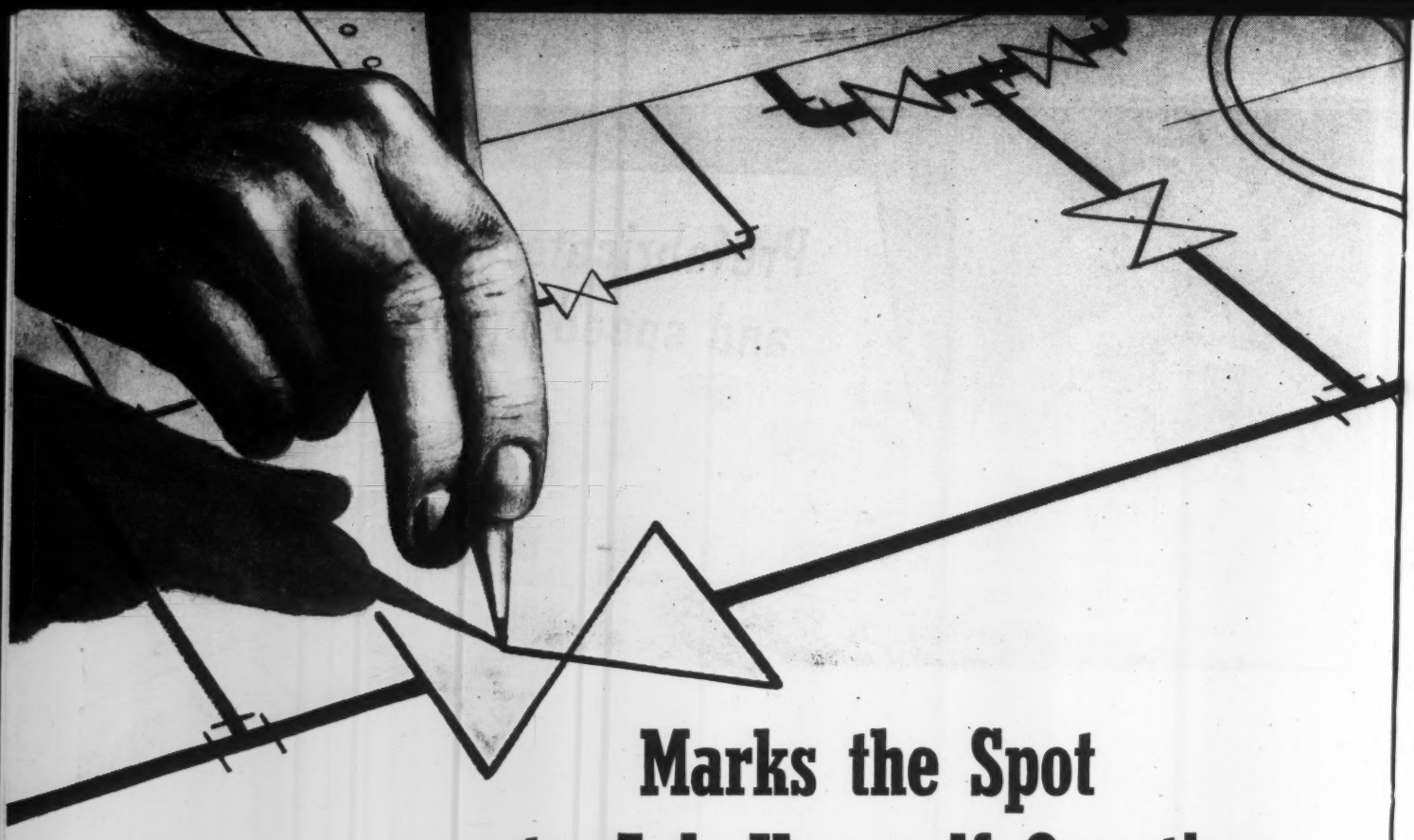


Fused into one piece

See how fitting and pipe are fused into one solid piece of metal, the welded joint actually stronger than the pipe metal itself

TUBE-TURN TRADE MARK *Welding Fittings and Flanges*





Marks the Spot to Ask Yourself Questions

When you draw the familiar "X" symbol to indicate a valve in plans for any product involving fluid control, stop and ask yourself these questions . . .

WILL it live up to the guarantee of the complete product, or will it soon start trouble and give the product a "black eye"?

WILL it assure the lowest cost in the long run, or will the saving of a few cents now be paid out many times over in later servicing costs?

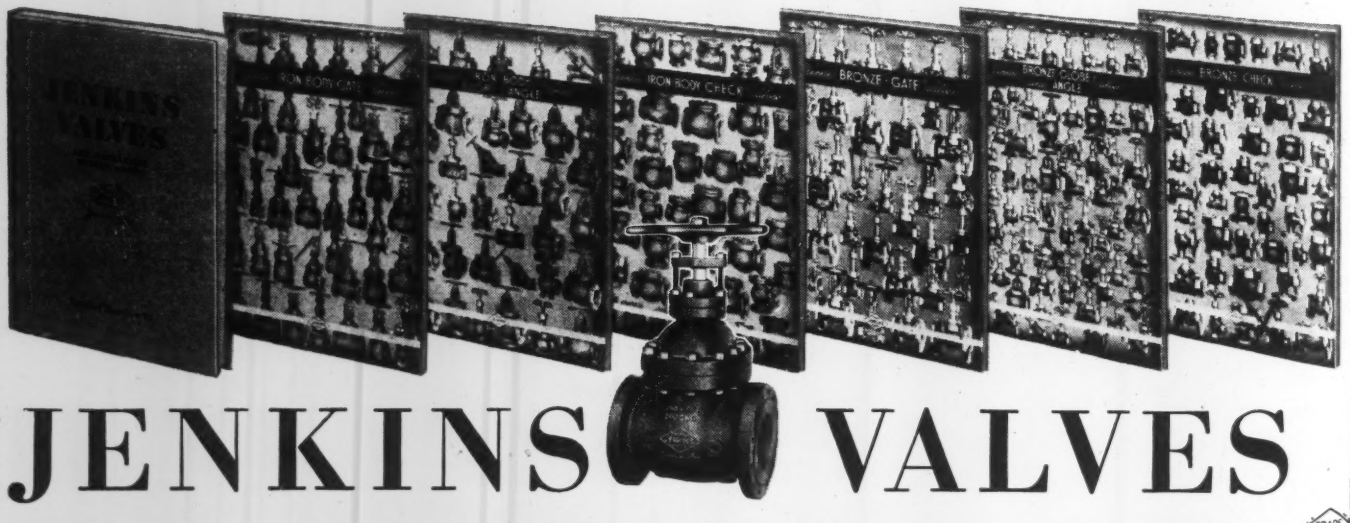
WILL the name on the valve signify "quality" to the product buyer, or is it relatively unknown, requiring that much extra sales effort?

IS the valve pattern the very best for the service, or am I overlooking some other pattern that would improve the product and add a sales advantage?

You can make sure of the right answers to these questions if you specify JENKINS whenever you specify VALVES. They have an 80 year record of top-notch quality, based on money-saving, trouble-free performance. And the famous Jenkins "Diamond" trade mark is known everywhere as the mark of trustworthy valves.

For the right answer to any questions on valve selection or application, talk to a Jenkins Sales Engineer. Give your product and its purchasers, the *extra value* of Jenkins Valves. Over 600 patterns for every service.

Jenkins Bros., 80 White Street, New York 13; Bridgeport, Conn.; Atlanta, Boston, Philadelphia, Chicago, San Francisco. Jenkins Bros., Ltd., Montreal, London.



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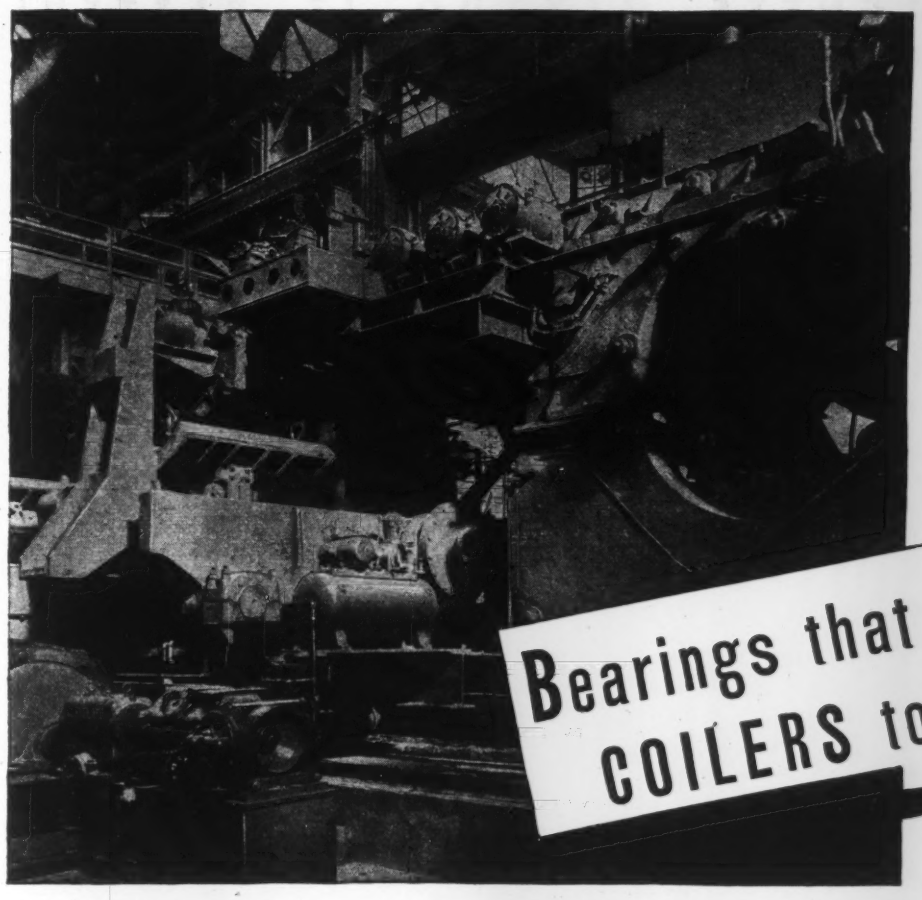

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It's easy to understand why SKF Spherical Roller Bearings are used to take the shocks and heavy loads of hot strip coiler operation. Their high load carrying capacity, undiminished by misalignment, makes it possible to fit an adequate bearing within space limitations. Their aligning ability prevents the concentration of shaft stresses . . . permits cool running at high speeds despite adverse circumstances. Our engineers will be glad to give you their unbiased answers to *your* bearing problems. 5875

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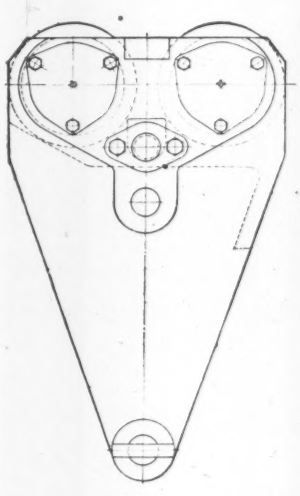

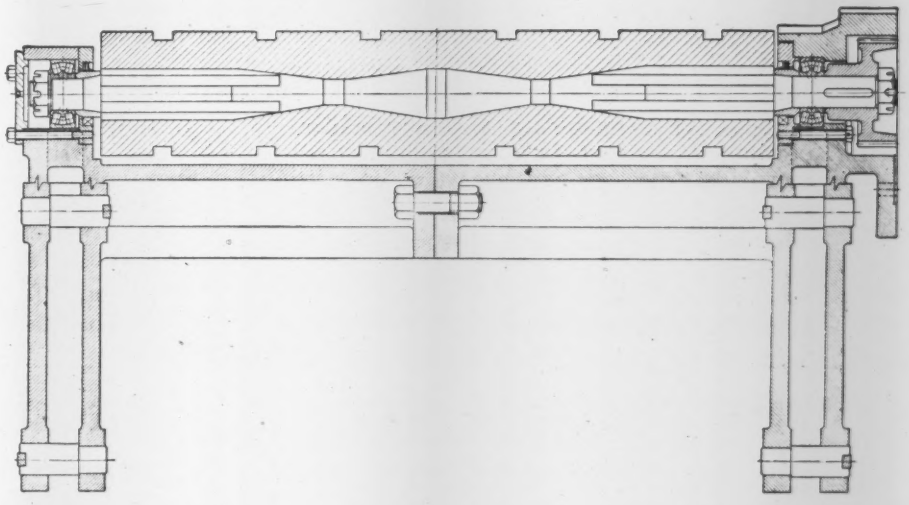

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New Engineering Handbook on Permanent Magnets

If you are considering any application of permanent magnets to your product or manufacturing processes, you are welcome, without charge, to a copy of this new *Manual*.

This is a 32-page, illustrated reference work on magnets, prepared by the engineering and research staff of the world's largest producers. It contains data on the functions of permanent magnets; an outline of basic types, with associated air-gaps; material characteristics; and information on their engineering, designing and manufacture. It has many useful formulae, charts, graphs and diagrams, of constant reference value.

Write today for your free copy of this *Manual*. Consultation with our engineers is invited.

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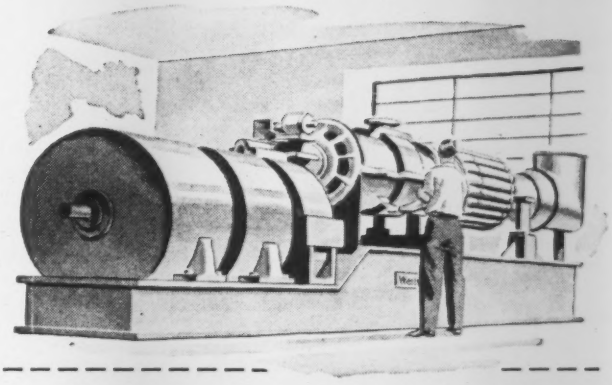
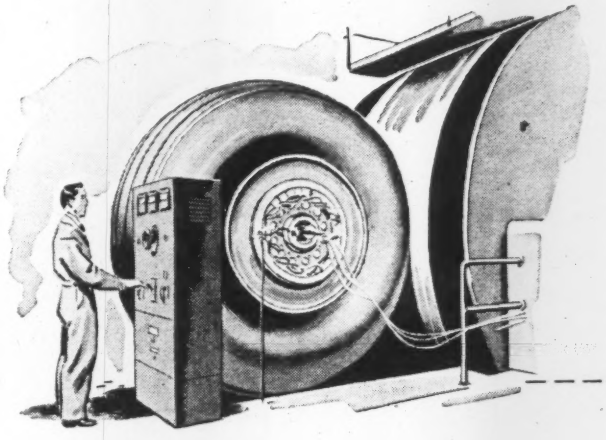
SPECIALISTS IN PERMANENT MAGNETS SINCE 1910

In a laboratory a SCIENTIST experiments with a new gas turbine . . . using heat-resisting alloy blades that are far stronger, at 1100°F., than *ordinary* steel at room temperature.

. . . the name on the GAS TURBINE is Westinghouse.





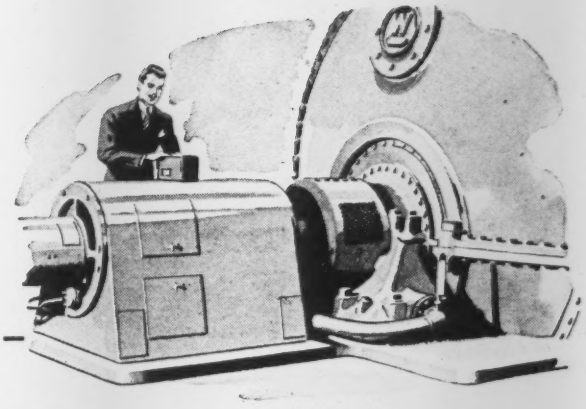
On a special machine a TESTER employs a Rototrol* for smoothly accelerating a large flywheel, used in determining the wear-resisting qualities of tires and brakes—for huge air transports of the future.

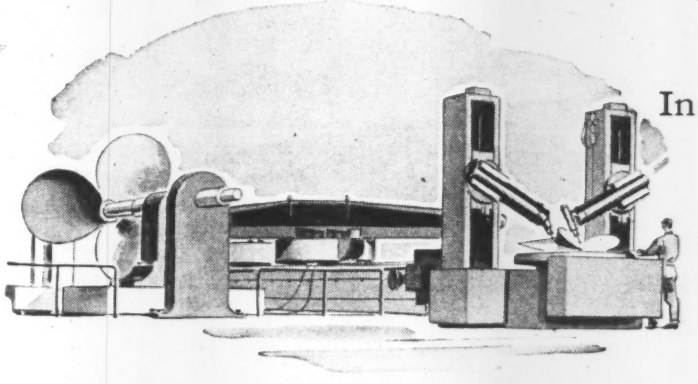
. . . the name on the ROTOTROL is Westinghouse.

*Registered Trademark

In a power plant an ENGINEER uses a Vibrograph to "take the pulse" of a turbo-generator . . . recording the smallest vibrations as a trace on a film.

. . . the name on the VIBROGRAPH is Westinghouse.





In a manufacturing plant an OPERATOR uses an electronic control to regulate the movement of milling cutters—for accurately machining irregular contours on giant ship propellers.

. . . the name on the ELECTRONIC CONTROL is Westinghouse.

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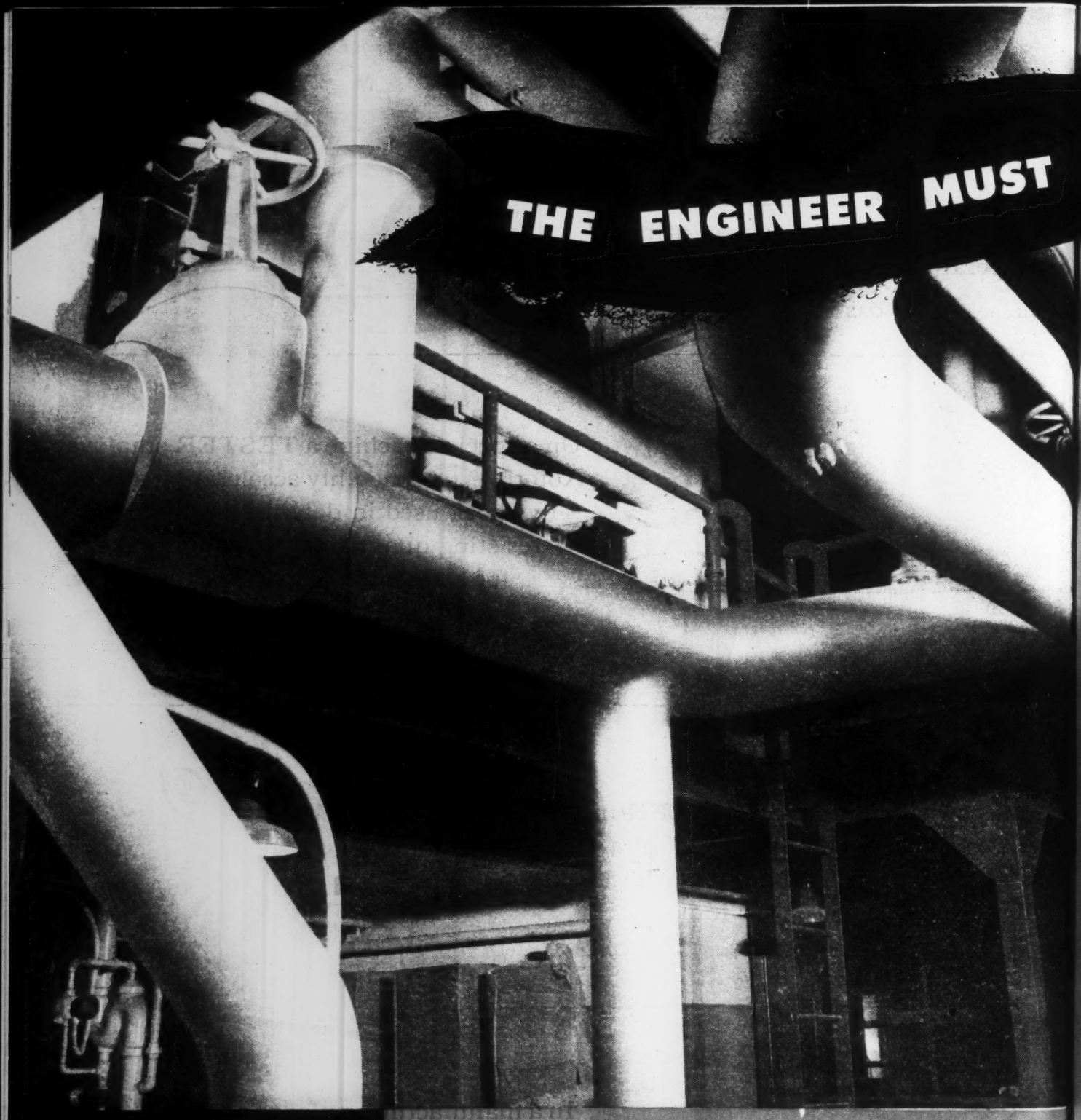

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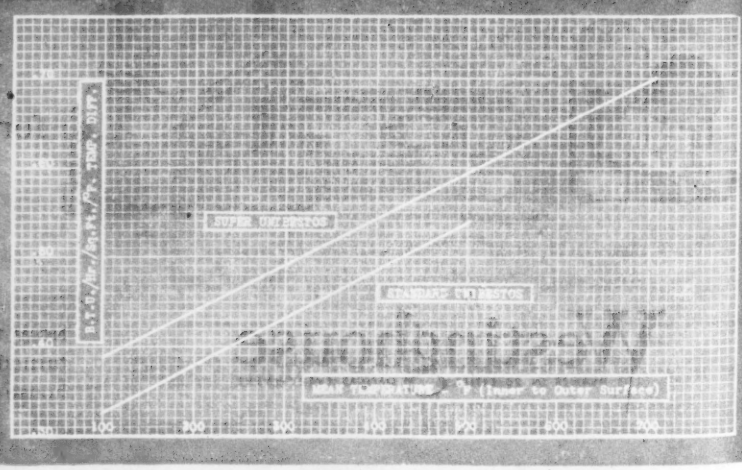

These Thermal Conductivity Curves tell the story!

THINK OF EVERYTHING

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MORE ECONOMICAL

UNIBESTOS

The Sectional Insulation

Unibestos is the *favorite* insulation because it is easier to apply (it's *the* half-section insulation) and more efficient (consequently more economical, both in application and in use) and because it makes for a better looking job. It won't sag, gap, shatter or shakedown under the most severe vibration—is unaffected by moisture. Unibestos saws or cuts clean and sharp with ordinary tools — provides a smooth, neat, efficient insulation.

For a step-by-step picturization of the application of Unibestos, write for your copy of "Efficiency"—bulletin No. 48-974.

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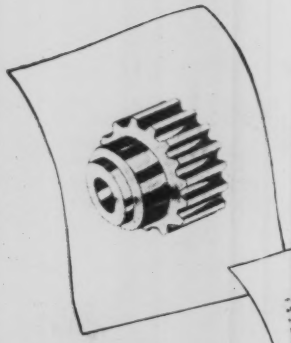

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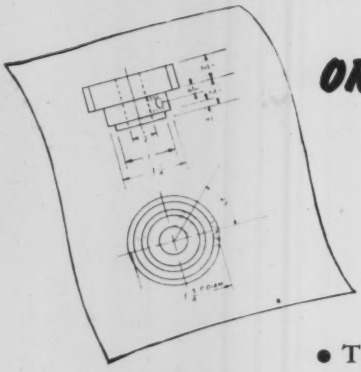

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Tops FOR TOP PRESSURES

On steam lines where pressures go as high as 1500 psi, and temperatures up to 900° F. are encountered, steam traps must be rugged . . . and *efficient!*

That's why so many public utilities and other high pressure steam plants are installing Yarway Integral Strainer Impulse Steam Traps. First cousin to the famous standard Yarway Impulse Steam Trap, the integral strainer trap has been developed especially to meet high pressure trapping requirements.

It has ample condensate capacity when system is being "warmed up." Yet it will handle relatively small amounts of condensate efficiently without losing prime. The valve closes positively in the presence of dry or superheated steam.

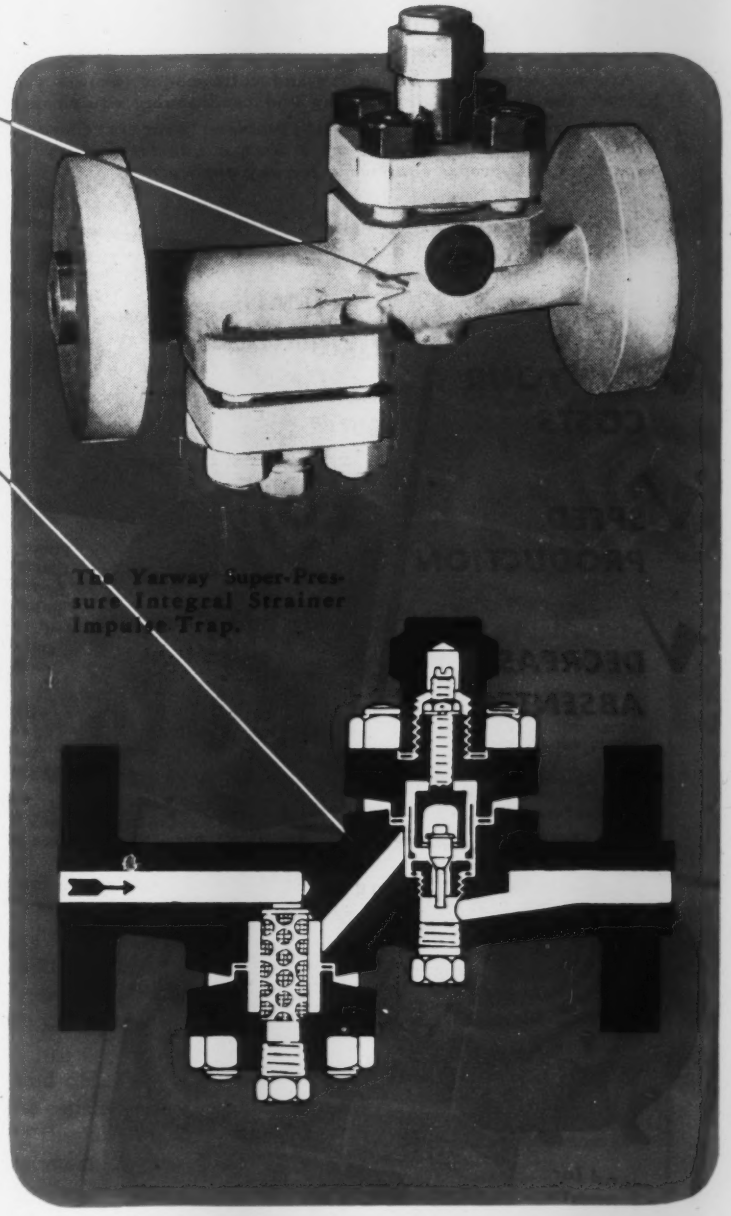
It is a fraction of the size and weight of other type traps designed for the same service—saving space, simplifying installation and requiring no supports.

It is suitable for all pressures within a wide range without change of valve or seat.

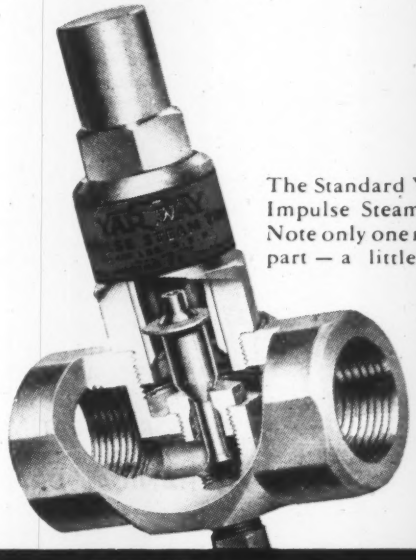
It has the same simplicity of design as does the standard Impulse Trap shown below—only one moving part, the same little valve.

Its integral strainer protects trap against scale and rust in the piping system.

Available with flanged or socket weld connections. Write for Bulletin T-1739.



The Yarway Super-Pressure Integral Strainer Impulse Trap.



The Standard Yarway Impulse Steam Trap. Note only one moving part — a little valve.

See these traps and other Yarway steam plant equipment . . . hear their operation described by Lowell Thomas in the Yarway color motion picture, "There Is An Engineering Reason." Available without charge for group showings. Write today.

YARNALL-WARING COMPANY
108 Mermaid Ave., Philadelphia 18, Pa.

YARWAY IMPULSE STEAM TRAP

The AIR in Your Plant—DOES IT HELP OR HINDER?

Neither manpower nor machines can do a 100% production job, unless the air is clean, pure and correctly temperatured.

Are you letting production lag and costs mount because you haven't the necessary air handling and conditioning equipment?

Thousands of plants turn such problems over to Clarage. We have developed, through more than a quarter-century of experience, the proper equipment for any application.

COOLING, HEATING, HUMIDITY CONTROL

Floor type unit shown above; space-saving, suspended type at left.

NO INSTALLATION DELAYS— "Whole Works" in One Assembly

Step up your production and insure lower post-war costs by maintaining the RIGHT atmospheric conditions. Clarage Multitherm (air conditioning) Units reduce this vital job to simplest form — low first cost; quickly installed without expensive building alterations; no ducts required.

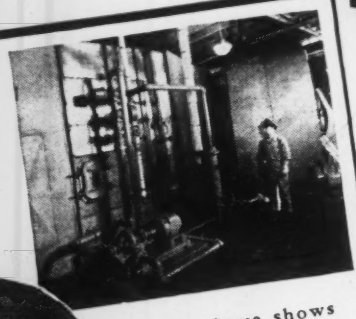
Units are available for cooling only, heating only, or complete, year-round control of temperature and humidity. Sizes to meet every need.

✓ CUT YOUR COSTS

✓ SPEED PRODUCTION

✓ DECREASE ABSENTEEISM

FRESH AIR Ventilation for Large Areas



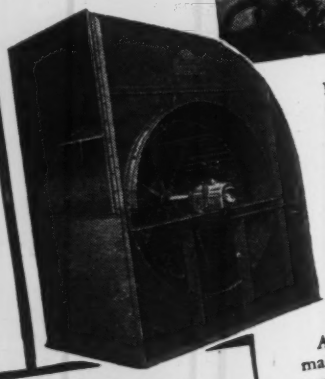


Photo above shows Clarage Ventilating System serving large industrial plant — fan at right; air washing and cleaning equipment at left.

Fans are built in 28 sizes; 500 to 100,000 c.f.m. — slow speed for belt drive; high speed for direct motor drive.

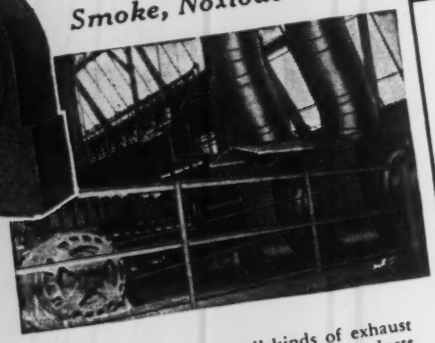
Air washers are "tailor-made" to meet individual service conditions.

READY UNITS for Small Space Ventilating

Here are ideal units for ventilating small factory or office areas — removing fumes and odors from laboratories, etc. The most complete line of small ventilating blowers on the market; 13 sizes with capacities 200 to 700 c.f.m. Most sizes can be operated from lighting circuit.

Built for long service without any attention except motor bearing lubrication.

Removing Dusts, Fumes, Smoke, Noxious Gases



—and for Pneumatic Conveying

Clarage Exhaust Fans are made to cover all kinds of exhaust and blow pipe needs — carrying away gritty, injurious dusts from emery and buffing wheels, fumes from chemical processes and paint spray operations — used wherever an industrial plant must be rid of atmospheric pollution.

As in all other Clarage Fans, wheels are both statically and dynamically balanced. Dust-proof, oil-tight bearings standard equipment. Large range of sizes.

Immediate Assistance Available in 45 Cities

Each of our branch offices is manned by experts — by Clarage application engineers with the "know how" to meet your particular requirements. Look for the Clarage number in your local phone book or write us at Kalamazoo.

COMPLETE AIR CONDITIONING
•
COOLING
•
VENTILATION
•
FACTORY HEATING
•
MECHANICAL DRAFT
•
FANS and BLOWERS for INDUSTRIAL NEEDS

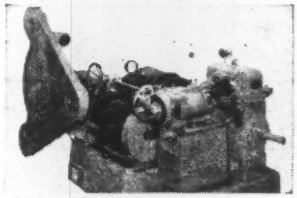
Clarage Fan Company Kalamazoo, Mich.

APPLICATION ENGINEERING OFFICES IN ALL PRINCIPAL CITIES

Oilgear Fluid Power extends range of amazing wire coating machines

The John Royle & Sons tubers are amazing machines that are coating millions of feet of wire with rubber or plastic insulation each week to meet the exacting requirements of the Signal Corps. Previously, not one of these tubers could produce its full capacity; the mechanical transmissions with which they were equipped originally just were not broad enough in their speed range to permit *one* standard tuber to coat *many* different sizes of wire uniformly with the required thickness of rubber or plastic.

But Oilgear Fluid Power could meet that need . . . and did. The Oilgear Transmission gives a broad range of controlled speeds to the capstan and rewind drive of this machine, enabling the latter to handle more sizes of wire and to do a much better job of coating the wire it handles. Similar benefits can be yours . . . if you will investigate the amazing possibilities of Oilgear Fluid Power for your straight line feeds or rotary drives. No matter what your power transmission problem is, you should know what Oilgear can do. THE OILGEAR COMPANY, 1307 W. Bruce St., Milwaukee 4, Wisconsin.



Oilgear Fluid Power enables this John Royle & Sons tubing machine to process many sizes of wire with required thicknesses of coating.

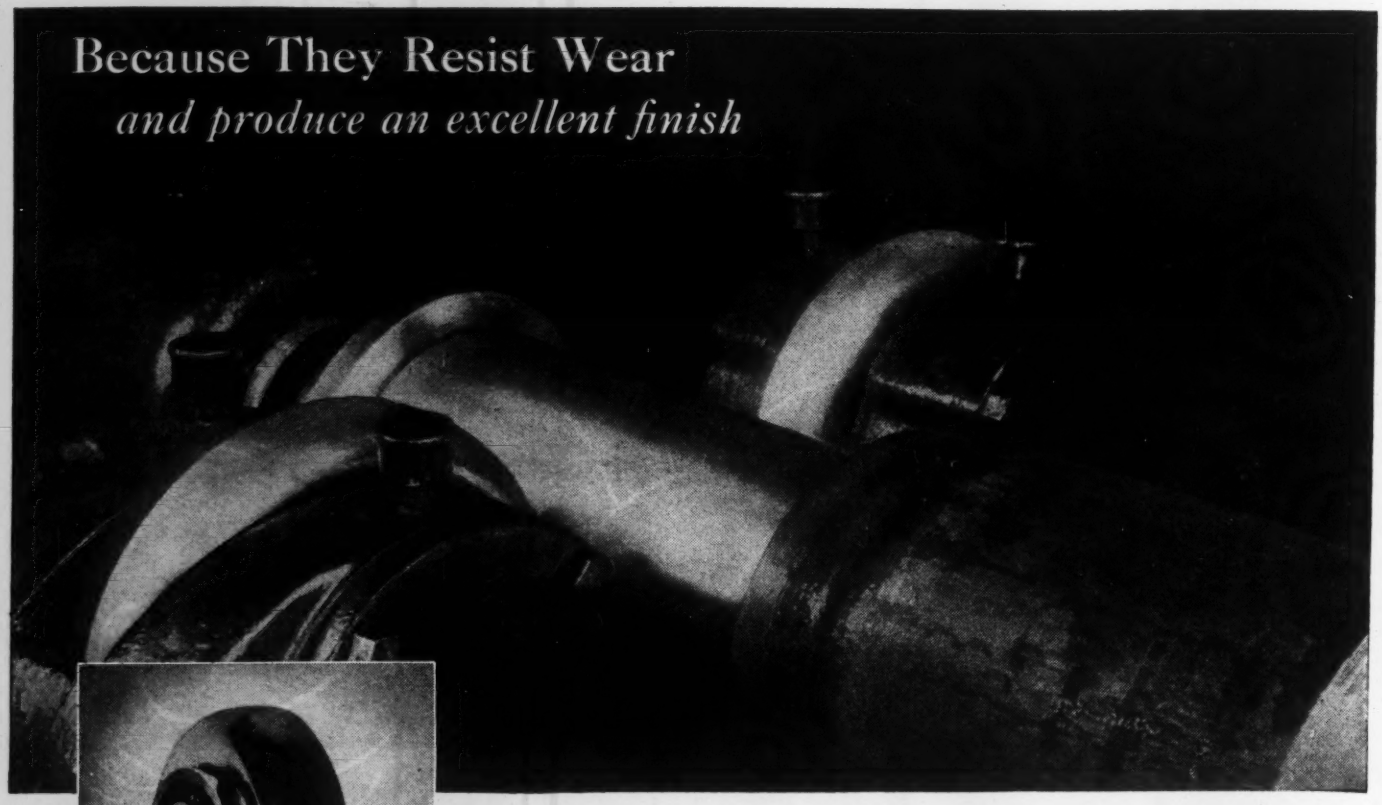
ARE YOU TRYING TO:

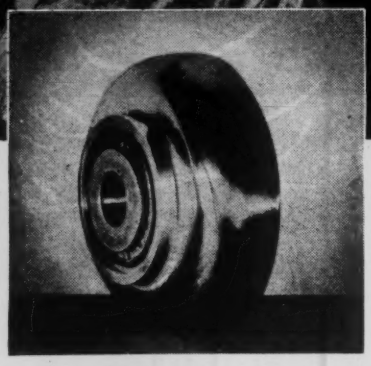
1. Apply large forces through long . . . or short . . . strokes at variable speeds?
2. Obtain automatic work cycles, variable speeds in either direction . . . with or without preset time dwell?
3. Apply large forces through continuous or intermittent reciprocating cycles at constant or variable velocities?
4. Obtain extremely accurate control of either position or speed of a reciprocating member?
5. Apply accurately variable pressure either static or in motion?
6. Closely synchronize various motions, operations or functions?
7. Apply light . . . or heavy . . . forces at extremely high velocities through either long or short distances of travel?
8. Obtain continuous automatic reversing drives at constant R.P.M. or over a wide range of speed variation?
9. Obtain accurate remote control of speed and direction of rotation, rates of acceleration and/or deceleration?
10. Obtain constant horsepower output through all or part of a speed range?
11. Obtain automatic torque control?
12. Obtain accurately matched speed of various rotating elements?
13. Obtain constant speed output from a variable speed input?
14. Obtain full preset automatic control, elimination of problems of shock, vibration, etc.?

You Need Oilgear!

OILGEAR *Fluid Power*

Because They Resist Wear
and produce an excellent finish





HAYNES STELLITE Burnishing Rollers are widely used in railroad shops

More than 100,000 car axles have been burnished in one railroad shop with one set of HAYNES STELLITE burnishing rollers. In eight years of hard service these rollers of cobalt-base alloy have required no repair or maintenance, except lubrication.

HAYNES STELLITE rollers not only resist wear, but also retain their high polish, and burnish to a high degree of smoothness. And because they are essentially non-magnetic, they are unlikely to pick up steel particles that will mar the work.

HAYNES STELLITE alloys are used in many tough industrial jobs where hard, abrasion- and corrosion-resistant metals are needed. Our engineers will be glad to help you use them. For further information, write for the booklet, "Products of Haynes Stellite Company."

In HAYNES STELLITE Alloys you can get these advantages:

1. **Resistance to wear and abrasion.**
2. **Hardness even at red heat.**
3. **Good mechanical properties at high temperatures over long periods of time.**
4. **Resistance to atmospheric corrosion and corrosive chemicals.**
5. **Low co-efficient of friction.**
6. **Practically non-magnetic.**
7. **Available in the form of castings, small sheets, and welding rod.**

BUY AND HOLD UNITED STATES VICTORY BONDS AND STAMPS

HAYNES TRADE-MARK *alloys*

HAYNES STELLITE COMPANY
Unit of Union Carbide and Carbon Corporation
UCC
General Office and Works, Kokomo, Ind.
Chicago—Cleveland—Detroit—Houston—Los Angeles—New York—San Francisco—Tulsa

"Haynes," "Stellite," "Hastelloy," "Hascrome," and "Haystellite" distinguish products of Haynes Stellite Company.

MODERN DEVELOPMENTS OF GASKET RESEARCH

BELLOWSEAL...

Here is a unique gasket design developed in the Goetze Research Laboratory — Bellowseal, type U-B.

It is a Serrated Type Gasket that literally uses the pressure to be sealed in, to exert a proportionate sealing pressure on the flange faces.

This gasket consists of two discs of metal (Armco Iron, Low Carbon Steel, Monel or Stainless Steel) machined on their external faces with standard serrations and welded together around their outer periphery.

It combines the pressure and corrosion resistant qualities of all metal gaskets with the light bolting requirements of a softer sealing medium. Line pressure entering the interior of the gasket exerts expansion pressure in excess of the required sealing force.

It makes sense, doesn't it? Let the pressure to be sealed seal itself against leakage.

Ask to have your name added to the list of engineers receiving "The Gasket" — a series of technical bulletins containing original gasket data emanating from the Goetze Research Laboratory. Write on your company letterhead giving your position.

GOETZE GASKET & PACKING CO., INC.
24 ALLEN AVENUE, NEW BRUNSWICK, N. J.

Boston	*New York*	*Philadelphia*	*Pittsburgh*
Cincinnati	*Cleveland*	*Detroit*	*Chicago*
Houston	*San Francisco*	*Los Angeles*	*Montreal*

Goetze for GASKETS

"America's Oldest and Largest Industrial Gasket Manufacturer"

Learn the story behind this damage

Cavitation-erosion ruined these blades. Especially designed to improve pump efficiency, this impeller was ruined by cavitation in less than four weeks. But the design was not abandoned. The eroded impeller was replaced with one made of a nickel alloy — "S" Monel. At last check, it was still in service after 2½ years — over a 3000% improvement!

A 5 MINUTE QUESTION AND ANSWER DIGEST ON CAVITATION-EROSION

THE PROBLEM

Q. What is meant by cavitation-erosion?

A. Cavitation-erosion (or simply "Cavitation") is the type of erosion caused by collapse of tiny bubbles in a liquid, with consequent hammering of the liquid against the metallic surface.

Q. Where may cavitation be encountered?

A. The inertia of a rapidly-moving liquid makes it tend to continue in a given direction rather than to follow the contours of the metallic surface over which it is flowing. This may create voids. The rush to fill them causes the cavitation. In power plants, for example, it is a particularly destructive phenomenon.

Q. Are these voids a complete vacuum?

A. No, the space is filled with vapor from the liquid and with dissolved gases that may be present.

Q. What causes the damage?

A. When the voids collapse, there results a pounding by the fluid comparable to the destructive force of tiny bullets impinging against the metallic surface. With thousands of voids collapsing every minute, the cumulative result is powerful enough to cause deformation and fatigue, and to remove films which might inhibit corrosion.

Q. How are cavitation and corrosion related?

A. Corrosion intensifies cavitation; and cavitation accelerates corrosion. Thus, a self-sustaining chain of destruction exists.

Q. How does corrosion intensify cavitation?

A. The roughened surface of a corroded metal affords greater opportunity for the formation and the collapse of voids.

Q. How does cavitation accelerate corrosion?

A. With many metals the initial corrosion rate is very rapid. However, the speed of the attack usually decreases due to the formation of protective films of the corrosion products. If these protective films are removed by cavitation, corrosion proceeds at an abnormal rate. *That is why use of corrosion-resisting metals and alloys is so important!*

THE REMEDY

Q. What important factors govern control of cavitation?

A. Laboratory and field studies indicate that the most important factors are:—

1. Proper design.
2. Resistance to corrosion fatigue.
3. Resistance to corrosion and freedom from pitting.
4. Tenacity of protective films, and speed of new film formation.
5. Strength, hardness, and ability of a metal to withstand over-stressing and to distribute locally-applied stresses.
6. Susceptibility to strain hardening.
7. Uniformity of grain structure.

Q. Why is design so important?

A. Poor design (inadequate streamlining) has proved to be the leading single cause of cavitation. And, its effect is intensified by a high velocity liquid flow.

Q. Doesn't this all boil down to developing the best design and selecting the right metal?

A. Yes! Both are very important and really interdependent. Sometimes a change in design will reduce cavitation. Sometimes, as in the impeller in the picture, the same design in a different metal will provide the remedy. *Consider both!*

Q. Design can be guided by skill and experience, but how can one be guided in selecting the right metal?

A. *Past performance!* Laboratory tests and field use have for years indicated that a group of high-nickel alloys should be considered wherever cavitation-erosion is a possibility.

Q. What is this group?

A. The corrosion-resisting INCO Nickel Alloys — nickel, Monel, "K" Monel, "H" Monel and "S" Monel. Their resistance to cavitation has been amply demonstrated by their successful use to replace other metals in high-speed propellers, pump impellers, hydraulic valves, agitators and in similar parts.

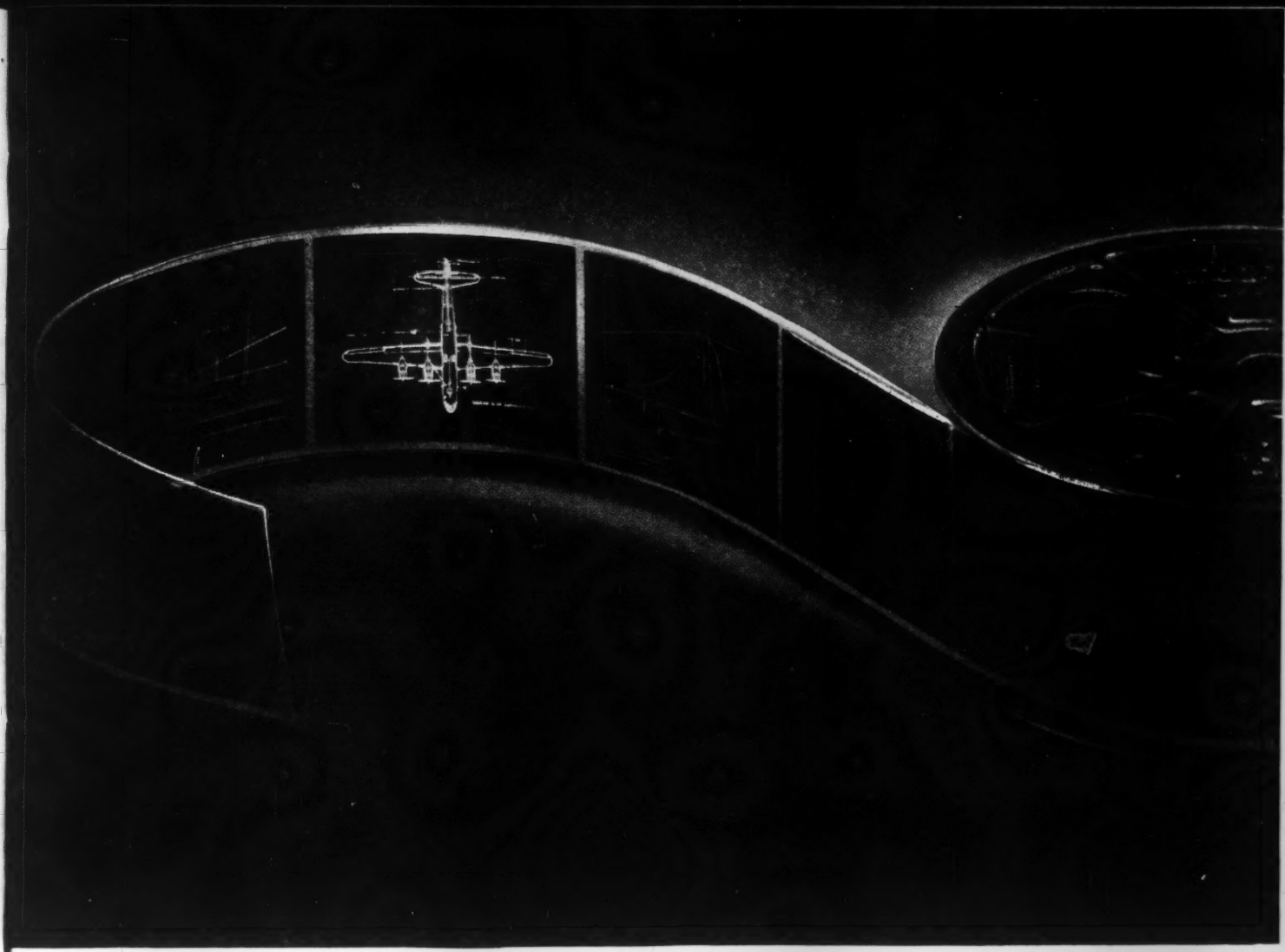
Q. Can INCO Nickel Alloys be used to build up parts that have already suffered cavitation-erosion?

A. Yes, and this ability is a big help on many repair jobs. For example, deposition of Monel or "K" Monel by arc-welding is an excellent way to build up eroded steel parts.

Q. How can more help be obtained on combating cavitation-erosion?

A. The International Nickel Company, Inc. has compiled a large amount of information on cavitation and will make all this accumulated experience available to anyone who needs it. Write: The International Nickel Company, Inc., 67 Wall Street, New York 5, N. Y.

Reprints of this advertisement are available upon request from The International Nickel Company, Inc.



Bomber . . . filed on film

Protect war drawings and records . . . file on space-saving, tamperproof microfilm . . . with Recordak!

★ Few manufacturers can afford to put war drawings in ordinary files. They're too numerous . . . too bulky and too important!

To protect them properly . . . keep them from swamping your files . . . microfilm them with Recordak. Then store the micro-size "files" in fireproof vaults. This will give you new protection against fire, theft, tampering, misfiling. Will reduce them to less than 1% of original area.

Recordak copies photographically—with the speed of light. It reproduces even big drawings on tiny microfilm. For reference or checking, images can be projected quickly in a Recordak Reader. Enlarged prints can be made from the negatives.

With Recordak you simplify filing of specification sheets, parts lists, and other engineering records. Save money, too. Film cost is only a fraction of a cent per item.

Nor are these the only efficiencies and economies Recordak brings to business and industry. If you want the whole story . . . as written by thousands of concerns making successful and imaginative use of it . . . mail this coupon. Recordak Corporation, Subsidiary of Eastman Kodak Company, 350 Madison Ave., New York 17, N. Y.

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Originator of modern microfilming

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Please send new free book about Recordak—"50 Billion Records Can't Be Wrong."

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16

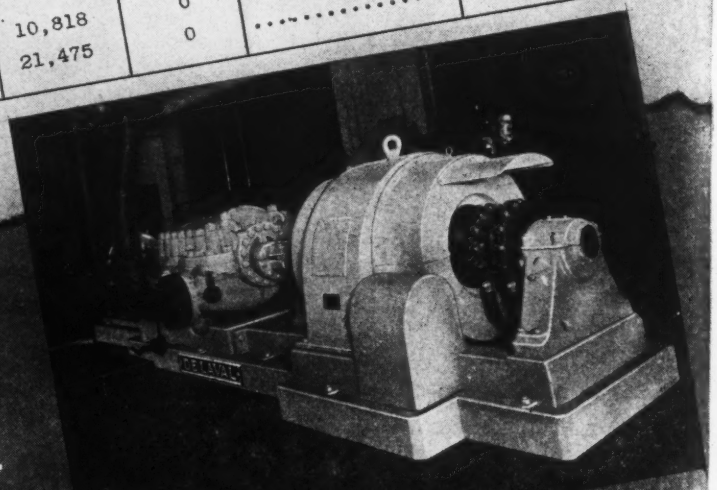
Look at the Record!

SERVICE RECORD—As of September 1, 1944

DE LAVAL PUMPS at _____

No.	Discharge Pressure psig	Suction Temp. °F.	Placed in Service	Total Service Hours	Outages Due to Pump	Cause of Outages	Approx. % Increase in Pump Power
14	1186	260°	12- 2-38	40,383	2	Replace ball locating bearing and shaft sleeves	Negligible
15	1186	260°	10-11-40	28,839	1	Replace shaft sleeves	Negligible
21	1186	350°	8- 4-39	10,818	0	.....	Negligible
16	1186	260°	1- 2-42	21,475	0	.....	5%

Capacity (all units).....1455 g.p.m.



of DE LAVAL HIGH-PRESSURE BOILER-FEED PUMP PERFORMANCE

Not one major trouble after as much as 40,000 hours of service!

The first of these units was installed in February, 1938; the most recent in February, 1942. All have demonstrated the satisfactory performance of De Laval boiler-feed pumps for high-pressure central station service.

Other important installations, operating at pressures up to 1600 psi and handling high temperature feed water, are operating with equal freedom from trouble, due in no small measure to the excellent performance of the De Laval automatic balancing device, the De Laval large clearance labyrinth wearing rings, and the sturdiness of De Laval solid end head construction.

3629

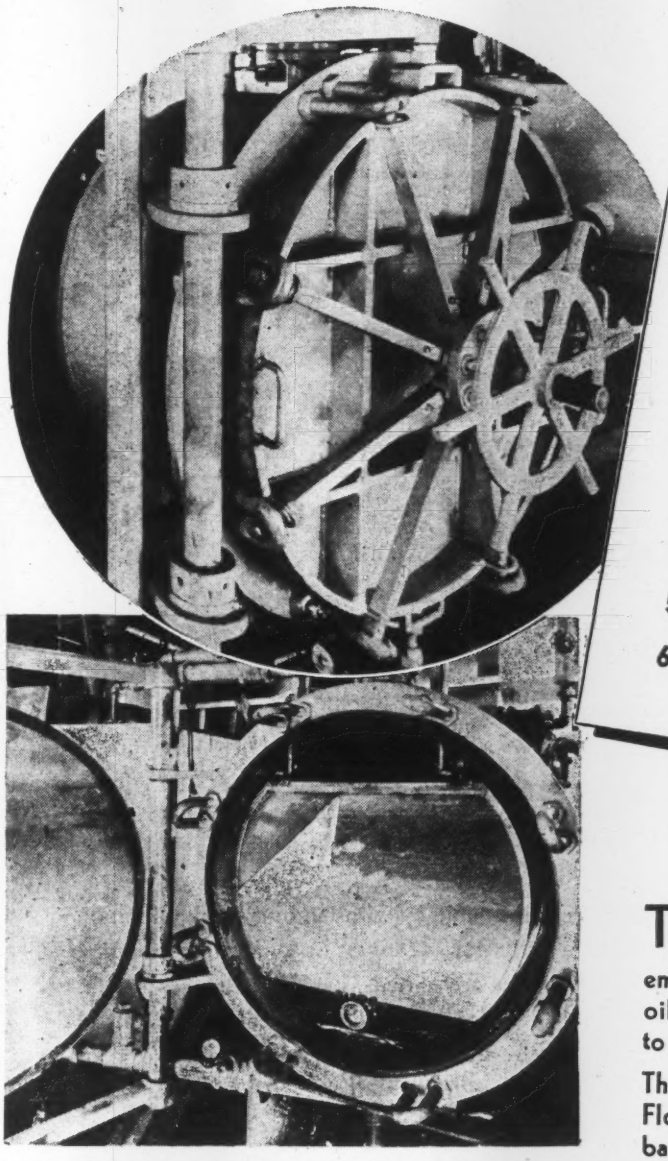
TURBINES • HELICAL GEARS • WORM GEAR SPEED REDUCERS CENTRIFUGAL PUMPS • CENTRIFUGAL BLOWERS and COMPRESSORS • IMO OIL PUMPS

DE LAVAL

STEAM TURBINE COMPANY · TRENTON 2, NEW JERSEY

SALES OFFICES: ATLANTA • BOSTON • CHARLOTTE • CHICAGO • CLEVELAND • DENVER DETROIT • DULUTH • EDMONTON • GREAT FALLS • HAVANA • HELENA • HOUSTON KANSAS CITY • LOS ANGELES • MONTREAL NEW ORLEANS • NEW YORK • PHILADELPHIA PITTSBURGH • ROCHESTER • ST. PAUL • SALT LAKE CITY • SAN FRANCISCO • SEATTLE TORONTO • TULSA • VANCOUVER • WASHINGTON, D. C. • WINNIPEG

Removes ALL OIL from condensed returns used for boiler feed



Upper picture shows the Refiner with special quick-locking door in place. Lower photo shows door open. Note how filter bed is peeled easily from pressure leaves in one piece.

APPLICATIONS

The REFINER can be used as a polishing filter for practically any liquid, including boiler feed water and condensate, alcoholic, malt and other beverages, chemicals, aromatics, paints, varnishes, lacquers, soaps, detergents, juices and liquid foods, and liquids used in processing other substances. The pressure-tight cylinder permits filtration of volatile, inflammable, and hazardous liquids. It also removes turbid matter of the same specific gravity as the liquid.

The REFINER

A revolutionary new filter PROVEN IN SERVICE

1. Eliminates oil entering boilers. Improves boiler efficiency Reduces boiler maintenance costs.
2. Saves heat units and fresh water by clarifying contaminated returns formerly dumped.
3. Removes free and EMULSIFIED oil from water to less than one-tenth part per million.
4. Requires no chemicals or wasteful back-washing.
5. Is simple, inexpensive to operate.
6. Requires little space

THE REFINER is an outstanding achievement in filters designed for extremely fine filtration. It breaks the tightest emulsion in condensate and removes both emulsified and free oil from an oil content as high as 90 parts per million down to a guaranteed maximum of one-tenth ppm.

The REFINER features compactness and low-cost operation. Flow rates of 20 to 200 gpm are obtained in single units. A battery of units provides greater capacities. The cost of filtered liquid by this new method of emulsion breaking is extremely low. No back-wash water is used.

The REFINER will greatly step up the efficiency of your plant and reduce boiler maintenance costs. Engineering assistance will be furnished gladly.

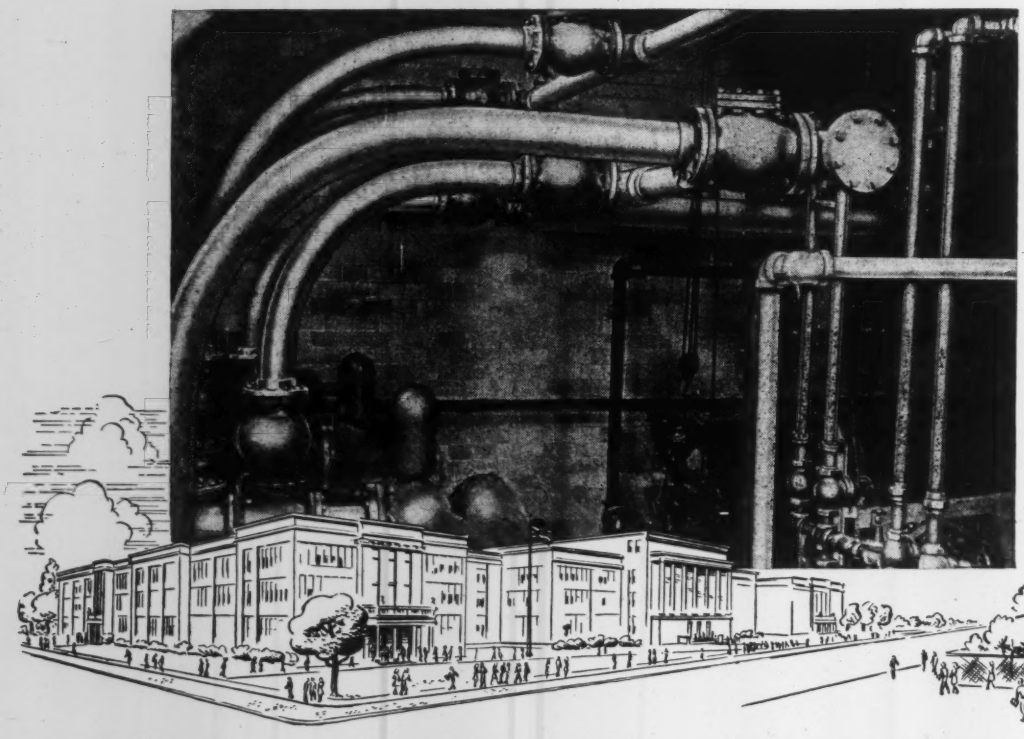
WRITE FOR CATALOG

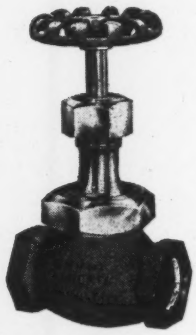
BLACKBURN-SMITH
MANUFACTURING COMPANY, INC.
For 60 years designers and manufacturers of filters
88 River Street, Hoboken, N. J.

Blackburn-Smith Mfg. Co. is a wholly owned subsidiary of Condenser Service & Engineering Co., Inc., builders of Evaporators, Stage Heaters, Gas Coolers, Drain Coolers and Heaters, Aftercoolers, Air Preheaters, Fuel Oil Heaters, Jacket Water Coolers, Process Heat Exchangers, Transformer Oil Coolers, Generator Air Coolers, Lubricating Oil Coolers, Storage Tank Oil Heaters, Feed Water Heaters, Distillers, Industrial and Oil Refinery Heat Exchangers, and other types of heat exchange equipment.

THE *Modern* METHOD OF JOINING COPPER AND BRASS PIPE

PIPING TROUBLE FORESTALLED BY walseal*





VALVES

FITTINGS

FLANGES

Silbraz* joints made with Walseal valves, fittings, and flanges assure the best service in brass or copper pipe lines. Wherever you see these modern threadless, silver-brazed joints, you can be sure that all joints are strong and leak-proof . . . and require neither maintenance nor repairs.

In this typical Silbraz installation in the boiler room of a large eastern college, copper and brass pipe lines have been made into "one-piece" lines by the use of Silbraz joints made with Walseal bronze valves and fittings. In many similar public edifices—and in countless other installations ranging from industrial plants to battleships — Silbraz joints and Walseal products have established beyond question their ability to forestall piping trouble by withstanding shock, vibration and corrosion for as long as or longer than the pipe to which they are joined.

Easily installed with an oxyacetylene torch, Walseal valves, fittings and flanges are made with a ring of silver brazing alloy incorporated into each port. When heated with the torch, this alloy melts and flows out to form a fillet between the pipe and the fitting or valve, making a tight, leak-proof Silbraz joint that is stronger than the pipe itself.

For full information on Walseal products and Silbraz joints — as well as Walworth's complete line of valves and fittings — write on your letterhead for a free copy of Catalog 42.

*Registered trade marks

MAKE IT A "ONE-PIECE PIPE LINE" WITH WALSEAL

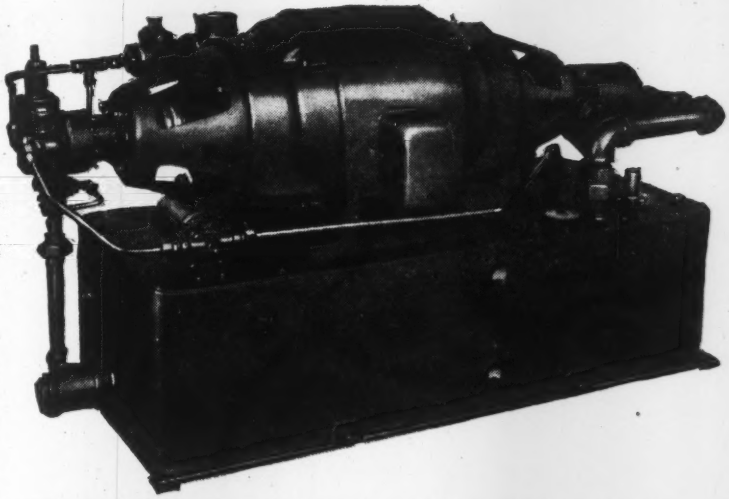
11 AWARDS
TO 4 PLANTS

WALWORTH

valves AND fittings

60 EAST 42nd ST., NEW YORK 17, N.Y.

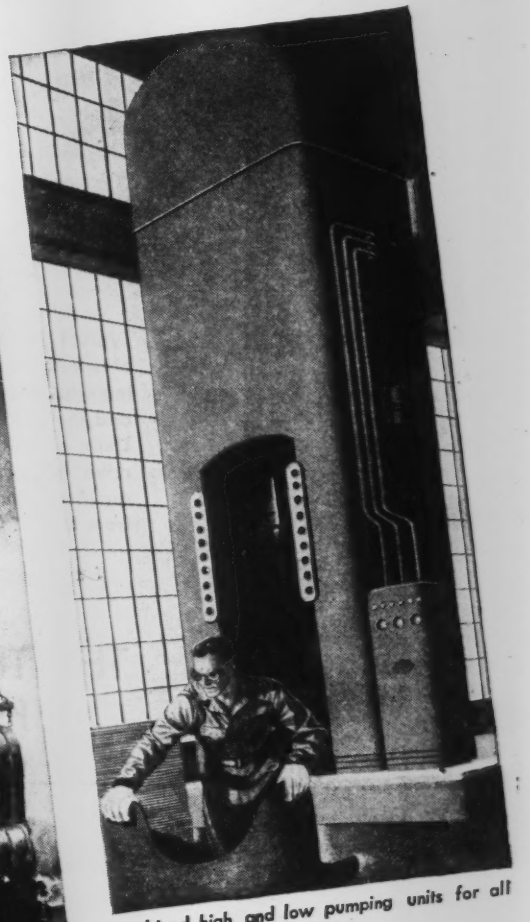
DISTRIBUTORS IN PRINCIPAL CENTERS THROUGHOUT THE WORLD



HYCON
Hydraulic Power

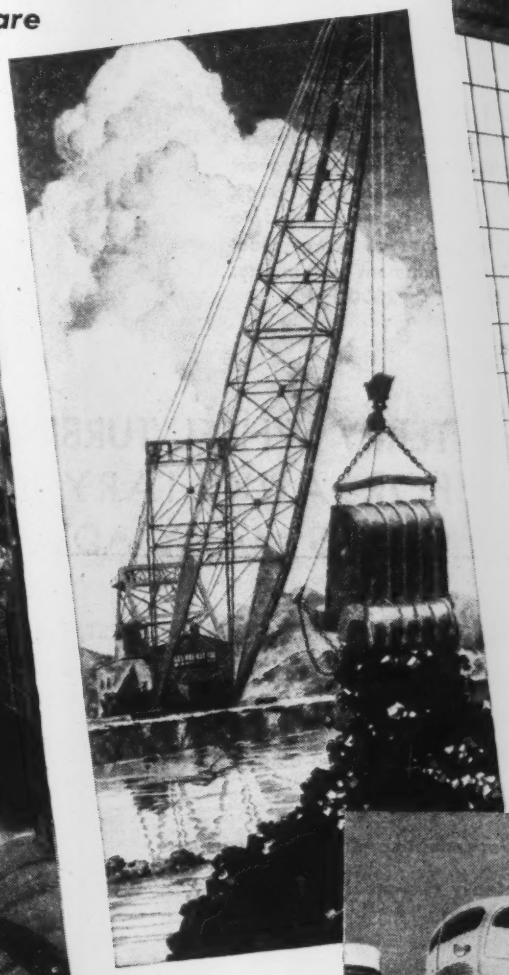
THE HEART OF THE MODERN MACHINE

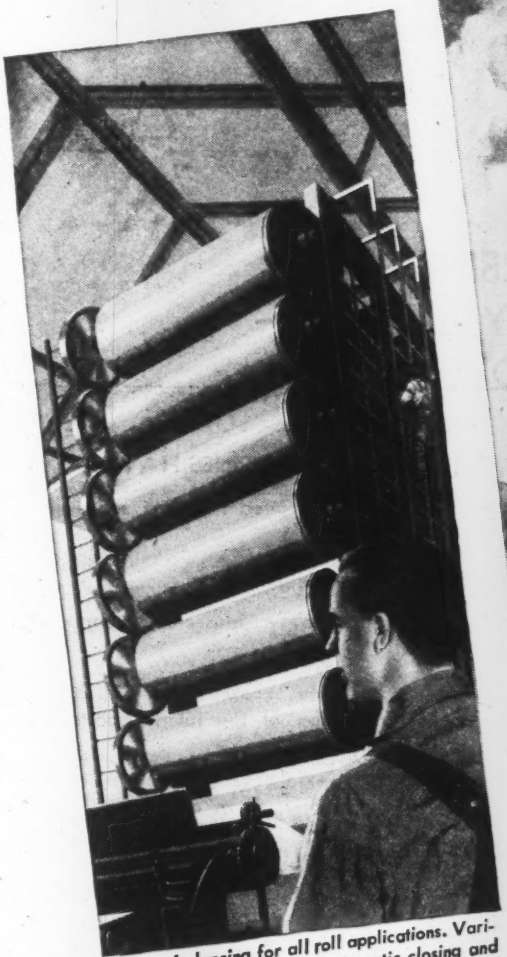
Hydraulic Power Units are
More Efficient
More Compact
More Economical



Combined high and low pumping units for all sizes and cycles.

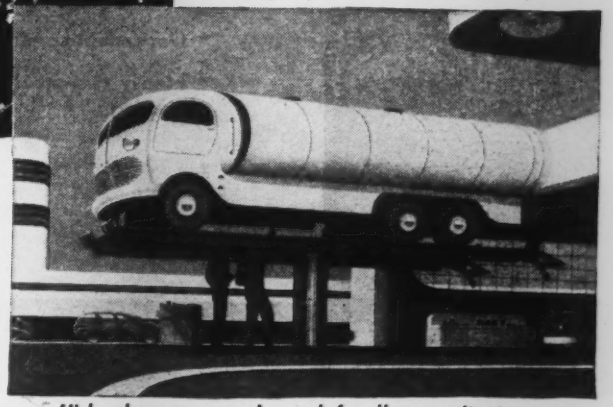
At left: Brake and clutch control for heavy construction equipment.





Pressure balancing for all roll applications. Variable controlled pressures, automatic closing and release.

WRITE US FOR PROPOSED LAYOUTS FOR YOUR POSTWAR PRODUCTS



High volume pumps and controls for all ram applications.

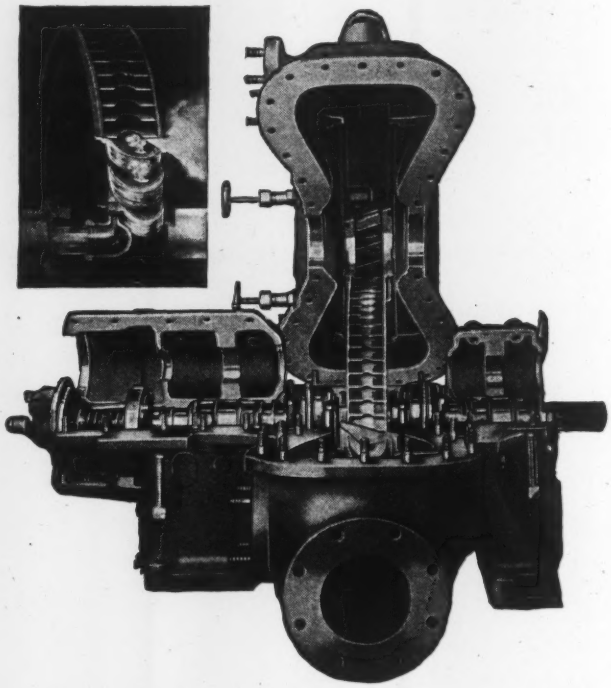
THE NEW YORK AIR BRAKE COMPANY

Hydraulic Division

420 LEXINGTON AVENUE, NEW YORK 17, N. Y. FACTORIES—WATERTOWN, NEW YORK

TERRY

Action of steam in Terry solid wheel and reversing chamber.



Typical Terry Solid Wheel Turbine with casing cover and bearing caps raised. Note ruggedness and the accessibility of all parts. Units of this type are used to drive all types of power plant auxiliary equipment built in sizes from 5 H.P. to 2000 H.P.

THE TERRY WHEEL TURBINE- FOR AUXILIARY DRIVE— OFFERS MANY ADVANTAGES

FROM THE SMALLEST TO THE LARGEST, THESE RELIABLE TURBINES HAVE—

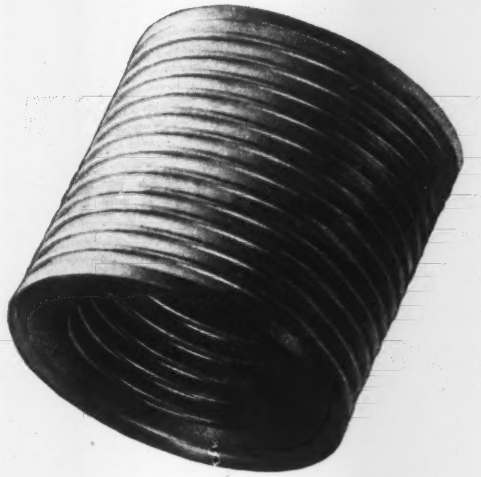
- ★ Indestructible one piece wheel.
- ★ Large radial and axial clearances.
- ★ Double rim protected blading.
- ★ Individual nozzle control.
- ★ Dependable and durable governor.
- ★ Heavy dust-proof bearing and governor housing.
- ★ Independent overspeed trip with separate valve.
- ★ Sturdy casing design.
- ★ Strong and easily inspected steam strainer.
- ★ Truly accessible construction, which makes inspection of the interior parts a simple matter.

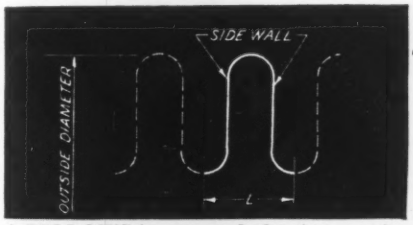
FOR FULL DETAILS ASK FOR BULLETIN S-116.

T-1157

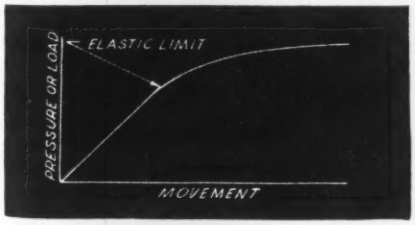
THE TERRY STEAM TURBINE COMPANY
TERRY SQUARE, HARTFORD, CONN.

BOTH ARE *One*-PIECE...





A BELLOWS is composed of active convolutions with an inactive convolution at each end. Drawing shows complete active convolution.



IF VALUES OF LOAD are plotted against stroke, a substantially straight line results for loads within elastic limit. This line begins to curve as limit is approached. When exceeded, line breaks sharply. Action of bellows is analogous to that of a helical spring.

. . . for flexibility and long life

LIKE A PRECISION-PROCESSED HELICAL SPRING, *action and life span of a Bridgeport bellows are completely predictable.*

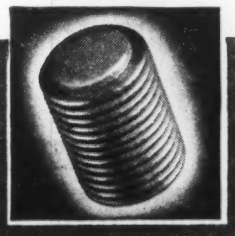
To begin with, each bellows is built to exact specifications . . . checked and re-checked at each step.

Metals used are carefully selected for each individual order . . . tested and re-tested.

In production, each bellows represents one piece of metal, a single disc, which is cupped and drawn into a tube, then formed into a deeply folded or corrugated unit. Forming may be mechanical or hydraulic or a combination of both processes, depending upon desired flexibility. Inspection is rigid, constant—from blank to finished bellows.

The result is bellows—a hundred, a thousand, or a hundred thousand, uniform in size, action and life span. *Known quality in any quantity!*

Write for further information about bellows, bellows assemblies and Bridgeport methods of production. Your request will bring Catalog XM-100 by return mail. Note page 17 particularly; also pages 6 and 7.



Bellows Assemblies . . . Bellows . . . Bellows Devices

BRIDGEPORT THERMOSTAT COMPANY, INCORPORATED—BRIDGEPORT 1, CONN.

TRADE

MAXITORQ

MARK

Floating Disc CLUTCHES

Machine Tool Builders . . .

HERE'S REAL CLUTCH PERFORMANCE

For your new machines . . . for improved operation, check on the new advantages inherent in the Maxitorq Floating Disc Clutch.

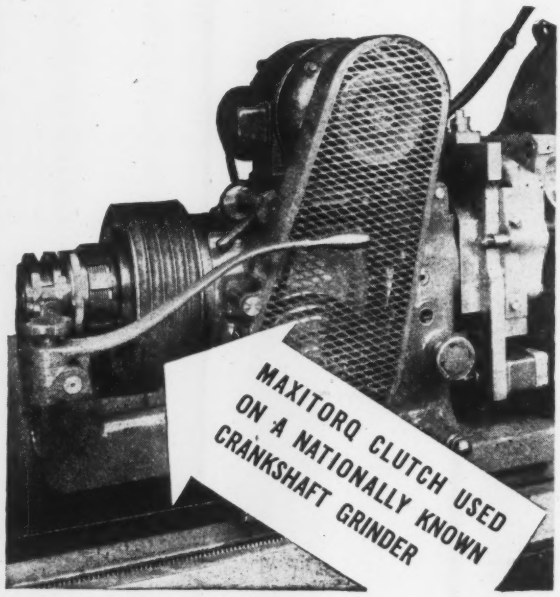
Here's a clutch that "comes out in the open." You can see every part. Without using any tools . . . not even a screw driver . . . you can take it apart, assemble, adjust it.

Separator Springs (a Maxitorq patent), used between the discs, "float" them in neutral. You can see between them. That means no drag, no abrasion, no heating in neutral. Thus, disc life is prolonged. There's no question about instant and positive engagement and disengagement . . . controlled with the lightest pressure.

This is a worthwhile clutch specification for your new applications . . . especially since Maxitorqs cost no more, often less, than less satisfactory units.

TYPES AND CAPACITIES

Maxitorq clutches are made in single and double (above) types, wet or dry. Pulley and cut-off coupling types also made. Capacities from ¼ to 15 H.P. at 100 R.P.M.



"MAXITORQ" *approved for . . . .*

The fast growing number of satisfied Maxitorq users is assuming the appearance of a "Who's Who" list of nationally known machinery manufacturers. A grinding machine, equipped with a Maxitorq, is shown above; others include packaging machinery, can labeling machines, commercial ice cream freezers, multi-spindle automatics, food, shoe and textile machines . . . and a host of others of equal importance.

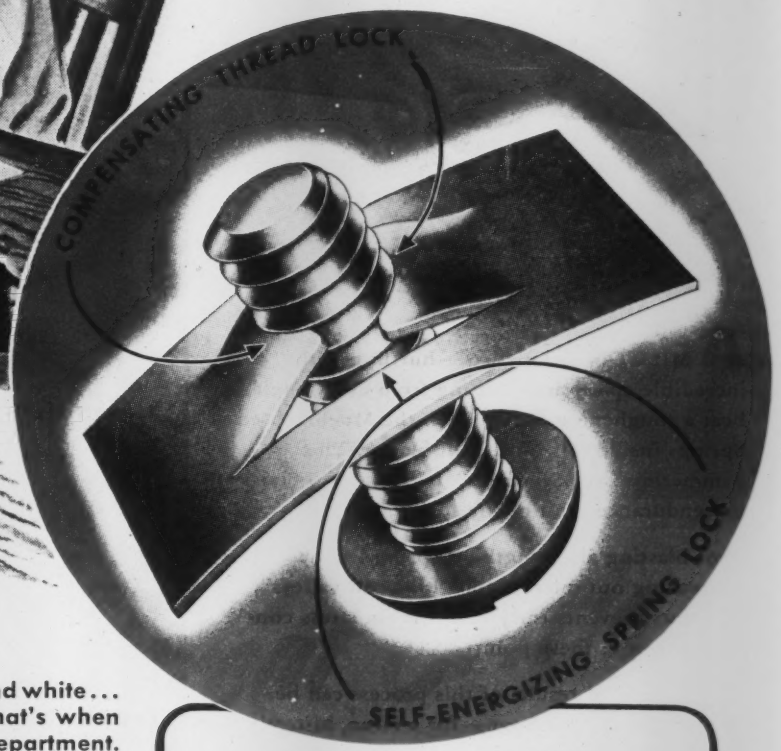
They couldn't take a chance on any but top class power transmission equipment. Neither can you. So look to Maxitorq for dependable solution of your problems.

Ask for Catalog No. ME-12.

THE CARLYLE JOHNSON MACHINE COMPANY · MANCHESTER, CONNECTICUT

WHY SPEED NUTS ARE FIRST

with Time Study and Cost Departments



When ALL assembly costs are down in black and white... when TOTAL net assembly costs are figured... that's when SPEED NUTS really show results in the Cost Department.

For SPEED NUTS reduce assembly costs in many ways. They completely eliminate lock washers—saving the cost of the washers *and* the time necessary to handle and install them. Moreover, hundreds of SPEED NUTS have been designed to perform multiple functions and eliminate two or more assembly parts.

SPEED NUTS are applied faster and easier to speed up assembly. They can't "clog" with paint or enamel to delay the assembly line. "Self-retaining" types of SPEED NUTS do away with expensive welding and clinching operations. And SPEED NUT spring-tension resiliency also protects porcelain, plastic or glass parts against damage in transit.

A letter describing your fastening problem will bring you full details on how SPEED NUTS will reduce YOUR total net assembly costs, too.

NOTHING LOCKS LIKE A SPEED NUT

Only SPEED NUTS provide a COMPENSATING thread lock and a SELF-ENERGIZING spring lock. As the screw is tightened the two arched prongs move inward to lock against the root of the screw thread. These free-acting prongs COMPENSATE for tolerance variations. Compression of the arch in prongs and base creates a SELF-ENERGIZING spring lock. These two forces combine to definitely prevent vibration loosening.

TINNERMAN PRODUCTS, INC.• 2124 Fulton Road, Cleveland 13, Ohio

In Canada: Wallace Barnes Co., Ltd., Hamilton, Ontario
In France: Aerocessoires Simmonds, S. A., Paris

In England: Simmonds Aerocessories, Ltd., London
In Australia: Simmonds Aerocessories, Pty. Ltd., Melbourne

Speed Nuts* PATENTED

* Trade Mark Reg. U. S. Pat. Off.

FASTEST THING IN FASTENINGS...OVER 3000 SHAPES AND SIZES

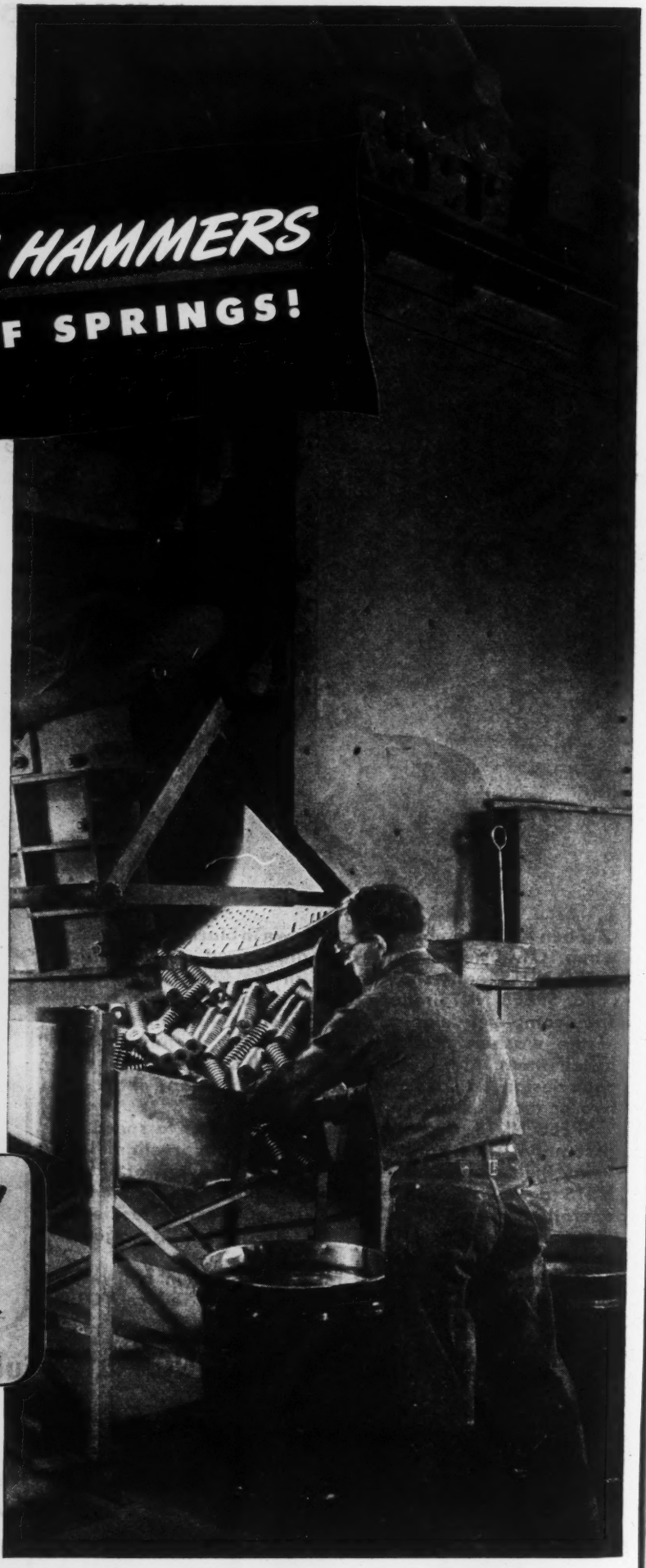
1,000,000 TINY HAMMERS ADD TO LIFE OF SPRINGS!

A MILLION tiny pellets—hurtling with incredible speed and striking from every angle—beat a toughening tattoo upon the Muehlhausen Springs inside this huge shot blaster. This hammering "work hardens" the surface to boost the endurance limit of the spring.

Shot blasting also lengthens spring life by smoothing out microscopic "hills and valleys", and thus prevents early failure from stress concentrations at these points.

The superficial results of this process can be seen with the naked eye—for a clean, lustrous finish is produced. But the more important results show up, only after years of service, in the lasting efficiency of Muehlhausen Springs.

MUEHLHAUSEN SPRING CORPORATION
Division of Standard Steel Spring Company
630 Michigan Avenue, Logansport, Indiana



MUEHLHAUSEN
MS SPRINGS
EVERY TYPE AND SIZE

TWO NEW FOLDERS—FREE
New booklet explains factors involved in correct spring design. Hot-Coiling Folder illustrates extensive equipment at Muehlhausen plant for making large springs.

O.K. of a Great Critic...

A WHOLE PLANTFUL OF THEM WHO BUILD MOTORS TO SATISFY EXACTING BUYERS!

Other plants may turn out *more* motors than the Star Plant. But you'll find no *better* motors . . . for when you see the Star Trademark you see the "O.K." on the efforts of hundreds of meticulous craftsmen working to critical standards.

Among them are the men who own the company. For Star's owners are born motor men, and the place to find them is out in the plant or around a drawing board, helping to make Star Motors as good as they can be.

Everybody at Star is exacting about quality . . . in design, materials, workmanship. There's a craftsman's spirit everywhere that words can't cover. But motor buyers who visit us always comment on it. And exacting motor users recognize that Star does things a bit better by specifying Star where a motor must be better than "good enough".

WRITE FOR 8-PAGE DIGEST. It outlines Star Motors (⅛ to 200 HP) and Generators (to 150 KW) . . . names hard-to-satisfy buyers who are long-time customers . . . tells how Star becomes the "Motor Department" for customers. Star Electric Motor Co., 230 Bloomfield Ave., Bloomfield, New Jersey.

STAR MOTORS

POWER PACKAGED AS YOU NEED IT

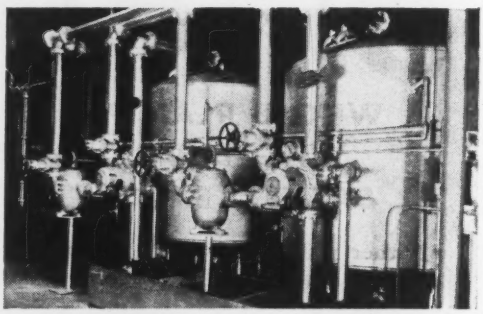
Permutit keeps boilers *clean* — by treating the feedwater before it enters the boilers

In today's heavily burdened power plant, it's easier than ever for impurities in feedwater to cause trouble: scaling and corrosion of boilers and steamlines, slowdowns—possibly even shutdowns.

You can wipe your hands of these troubles with Permutit* conditioned water. Permutit *removes* the impurities in feedwater *before it enters the boilers.*

Manufacturers of water conditioning equipment for over 30 years, Permutit provides *every* process for control of water quality. This includes the Zeo-Karb Water Conditioner (illustrated), Hot and Cold Lime Soda Softeners, Deaerating Heaters, Continuous Blowoff and Demineralizers that deliver a low-cost substitute for evaporated water.

Let Permutit help you prevent boiler scale and corrosion in your steam plant. Write to The Permutit Company, Dept A3, 330 West 42nd Street, New York 18, N. Y. or Permutit Co. of Canada, Ltd., Montreal.



PERMUTIT ZEO-KARB* H WATER CONDITIONER removes both hardness and bicarbonates from water. Effluent contains no incrustants, is reduced in total solids and alkalinity. Alkalinity can be adjusted by mixing effluents from a Zeo-Karb H unit and a sodium zeolite unit.

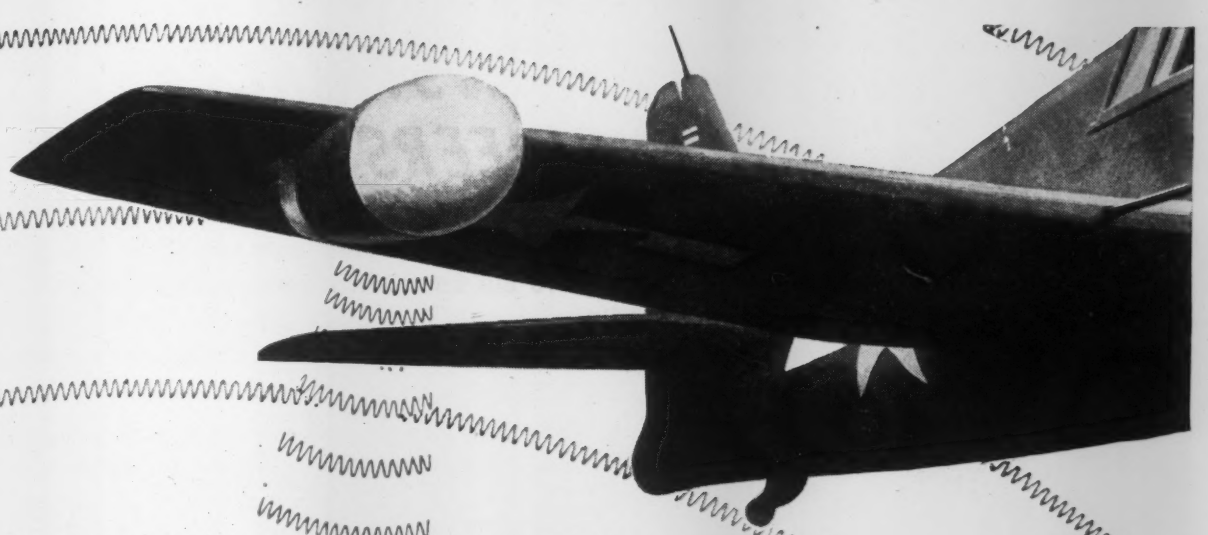
*Trademarks Reg. U. S. Pat. Off.

PERMUTIT

Manufacturers of ALL types of water treatment equipment

It's good business to begin with Good Water

WATER CONDITIONING HEADQUARTERS



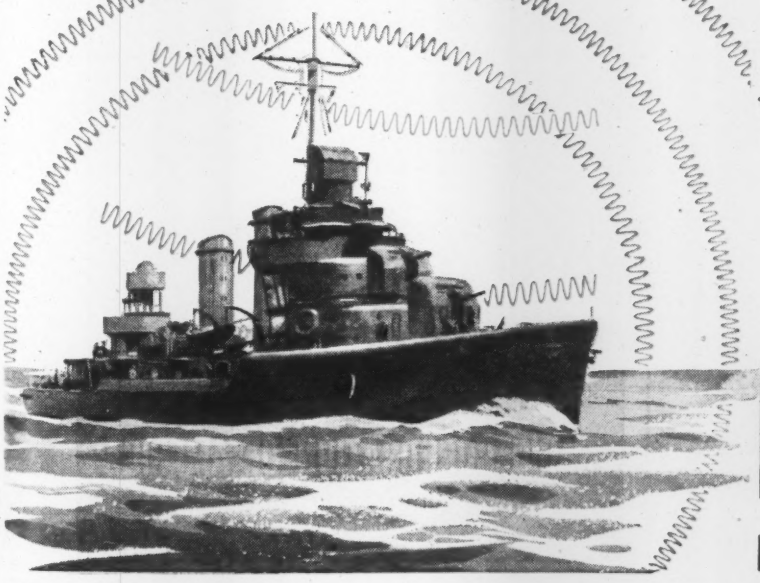
PRESENTING THE CASE FOR RADAR

AS THE STORY of radar unfolds, the nation becomes increasingly aware of the extreme importance of this one-time "secret weapon." And behind *that* story is another—about radically new types of housings that had to be developed before radar could perform its vital functions on land, at sea, and in the air . . . housings called radomes.* Certain types, such as the radome illustrated, were produced from woven glass cloth and BAKELITE laminating resins.

Manufacturers, designers, and engineers will be interested in the exceptionally exacting requirements that were met: low power factor and low dielectric constant at high radio frequencies; high tensile, flexural, and compressive strengths; and extreme weatherability. Still other advantages of this new and superior electrical insulating plastic included good color stability and resistance to marine growths. Productionwise, these laminated radomes were formed at low fabricating pressures, in comparatively inexpensive molds. They demonstrate the practicality and economy of forming large, intricate shapes by this laminating-molding technique at pressures frequently as low as one pound per square inch.

Write Department 56 for further information on BAKELITE resins for high-, low-, and contact-pressure laminating, and the names of the suppliers of the finished laminates.

*Radome illustrated through courtesy of Andover-Kent Aviation Corp.



TRADE (B) MARK

BAKELITE CORPORATION

Unit of

Union Carbide and Carbon Corporation

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BAKELITE

TRADE-MARK

LAMINATING PLASTICS

FREE. TO INDUSTRIAL ENGINEERS AND EXECUTIVES

20-page booklet showing how electronic equipment is being used in industry today—to cut costs, increase production, and improve product quality

CONTENTS—How Electron Tubes . . .

- protect workers
- analyze colors
- control lighting
- provide high-speed switching
- "time" machine-tool operations
- speed wood-bonding 700%
- sort mountains of beans
- provide split-cycle timing
- speed soldering 2400%
- direct traffic
- prevent fire and explosion
- speed surface hardening
- test springs
- dry penicillin 4700% faster
- prevent paper waste
- detect hidden flaws in metal

HERE—in convenient, easy-to-read form—are sixteen authentic case histories, telling how different industrial electronic devices work, and how they have saved time, money, and materials, for many different industries. Simply written, non-technical, illustrated, these case histories contain many ideas that may be useful to you.

What the booklet can do for you—Any of the ideas discussed in this booklet may suggest ways in which *your* company can adopt electronic methods to save money, increase production, perform manufacturing operations not possible by other means—or ways in which electronic devices can be designed into the products you manufacture to provide improved performance.

Authentic case histories—Case histories like these, which have appeared in RCA advertising for over two years, have attracted much favorable comment from industrial engineers and executives. Because the information they contain has proved so useful, 16 of the most popular applications have been reprinted in this 11" x 14" booklet.

Send for YOUR copy today—For your free copy of this booklet, write to us for "16-Examples Booklet," or simply attach the coupon below to your company letterhead. Please indicate your position, and mail it to us *today*.

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Your booklet, "16 Examples of RCA Electron Tubes at Work in Industry," containing authentic case histories of industrial electronic applications (with photographs, drawings, diagrams, etc.) is of interest to our company. Please send my free copy to:

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The Fountainhead of Modern Tube Development is RCA

BUY BONDS AND KEEP 'EM!

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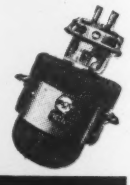
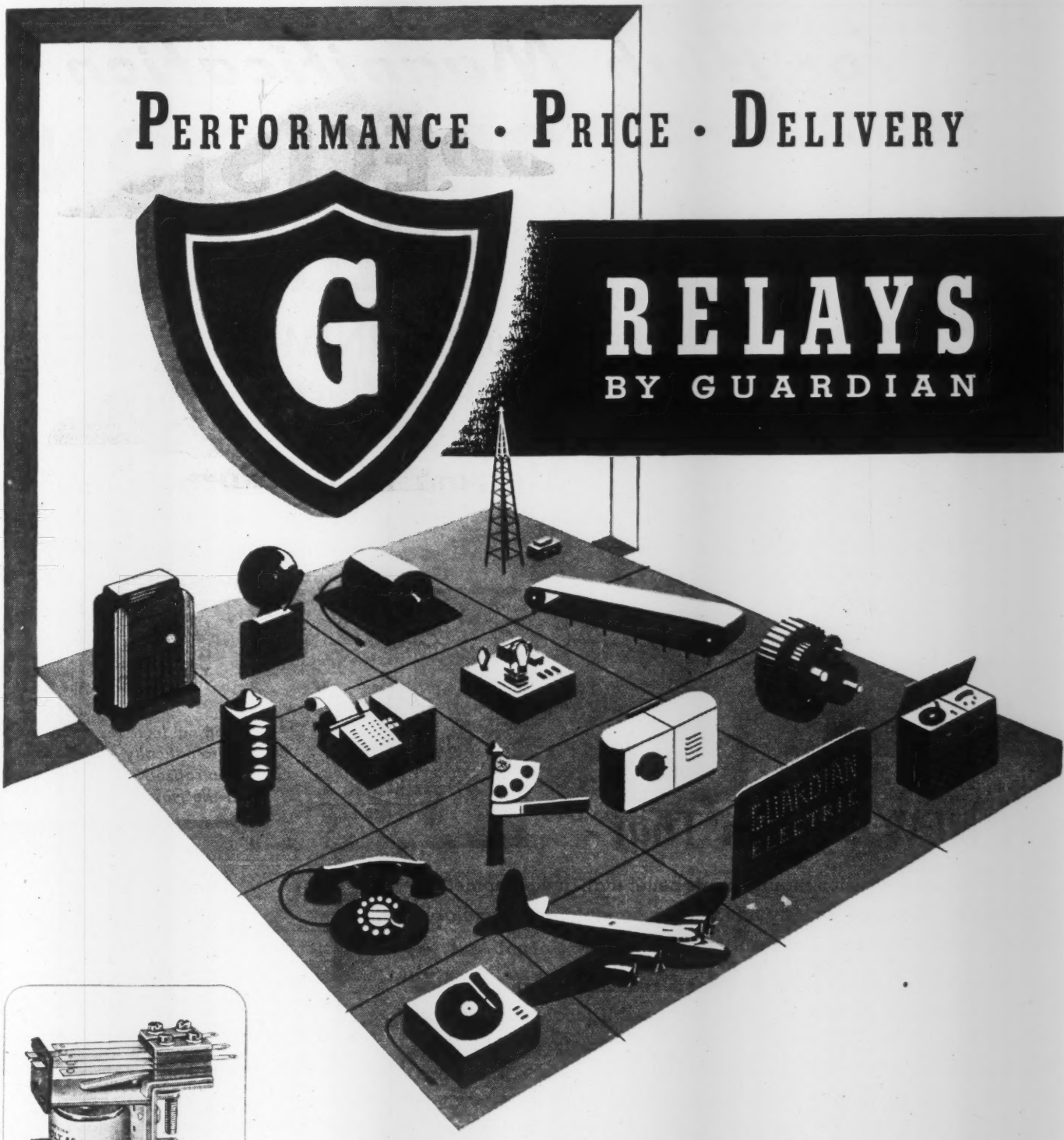


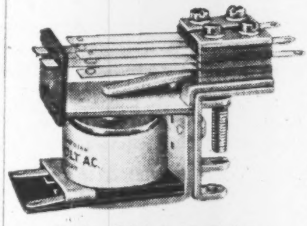
RADIO CORPORATION OF AMERICA

TUBE DIVISION, HARRISON, N. J.

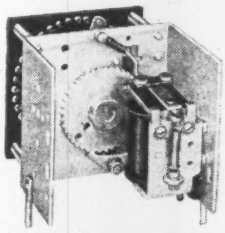
PERFORMANCE · PRICE · DELIVERY

RELAYS
BY GUARDIAN





Series 100 A. C. Relay



Series R Stepping Relay

More and more of today's instruments, appliances and machines start, stop, see, hear, measure, count, time, record, talk, fly, with Relays by Guardian. Manufacturers who designed these products thought they needed "specials", yet found Guardian *standard* Relays better qualified on performance—price—delivery. For example, the Guardian Series 100 Relay is a standard type with replaceable coil and contact combinations available. Has a wide operating range from 3 v. to 230 v. at 60 cycles. Another unit, the Series R Stepping Relay is built for three basic types of A.C. and D.C. operation: 1. Continuous rotation; 2. Electrical reset; 3. Add and subtract. These and other Guardian controls and Guardian's speed and flexibility of manufacturing can make things easier for you. Send for NEW RELAY CATALOG showing 43 basic types of relays, a complete line of solenoids, magnetic contactors, switch parts, together with operating data, specifications, suggested applications. Your catalog is waiting. No cost. Write.

GUARDIAN ELECTRIC

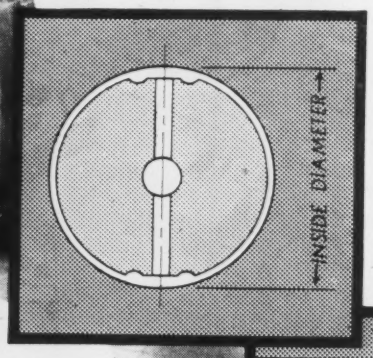
1619-P W. WALNUT STREET CHICAGO 12, ILLINOIS

A COMPLETE LINE OF RELAYS SERVING AMERICAN INDUSTRY

for High Magnification

PRECISION GAGING

— with MINIMUM *Human Influence and* NO *Marring of the Surface*



SCALE MEASURES DIRECT

(.0001") *Looks like This* —

Gaging Jets Automatically Centralized in the Hole

Actual Size

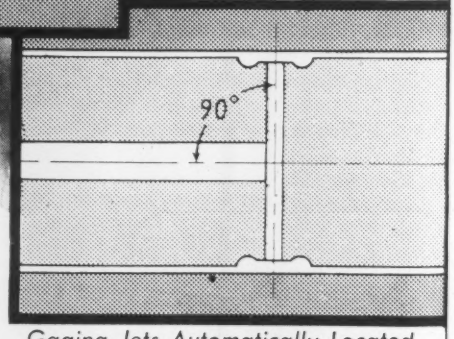
A NEW System That -

meets certain precision requirements better than any other method of gaging. It includes many advantages heretofore not available in gages using air as a measuring medium.

This Federal Metricator Gage System reduces human influence to a *higher degree* than any other method; it *locates* the gaging head precisely. It has extremely *high* magnification. • The scale measures *direct* as well as compares dimensions. • Therefore, practical for selective inspection and Quality Control. • Only one master required. • Plugs are interchangeable *without* changing scale. • Tolerance maintained *regardless* of plug wear. *Several* dimensions can be gaged simultaneously.

Rugged, fast and simplest to install. Write for details to

FEDERAL PRODUCTS CORPORATION
1144 EDDY STREET PROVIDENCE 1, R. I.



Gaging Jets Automatically Located Perpendicular to Axis of the Hole.

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FEDERAL AIR MECHANICAL *and* ELECTRONIC GAGES

PRECISION MEASURING INSTRUMENTS

TRAPPED!

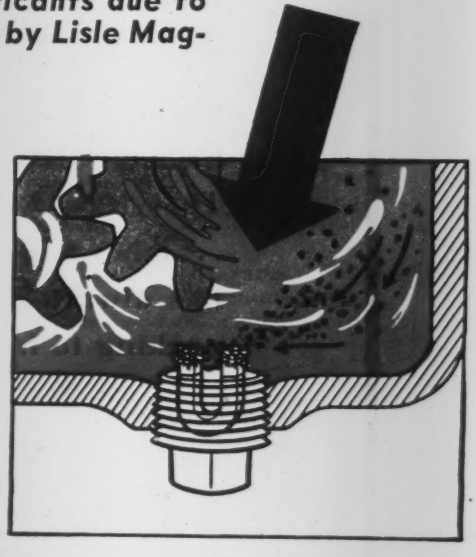
The Royal Bengal Tiger is a fighter, 500 lbs. of brawn, and hard to capture. Asiatic natives most often trap him in home-made cage traps. Bait is staked to the floor, and when the tiger enters, a trigger drops and latches both doors.

TRAPPED!

Dangerous, abrasive metal which forms in lubricants due to wear. This metal is now TRAPPED and removed by Lisle Magnetic Plugs, before it can do damage.

TINY metal particles, sharp as razors, churning and circulating in bearings, gears, and moving parts — These are a major cause of premature wear in many products — flaking off all the time — collecting in the lubricant — grinding away constantly at delicate surfaces.

Now you can TRAP such harmful metal as fast as it develops, by using Lisle MAGNETIC Plugs in place of ordinary drain and fill plugs. A powerful magnet in each Lisle Plug reaches into the oil, PULLS out the abrasive particles, HOLDS them securely until cleaned off. Lisle Plugs come in all standard sizes, cost little more than ordinary plugs, retain their magnetism for 10 years.

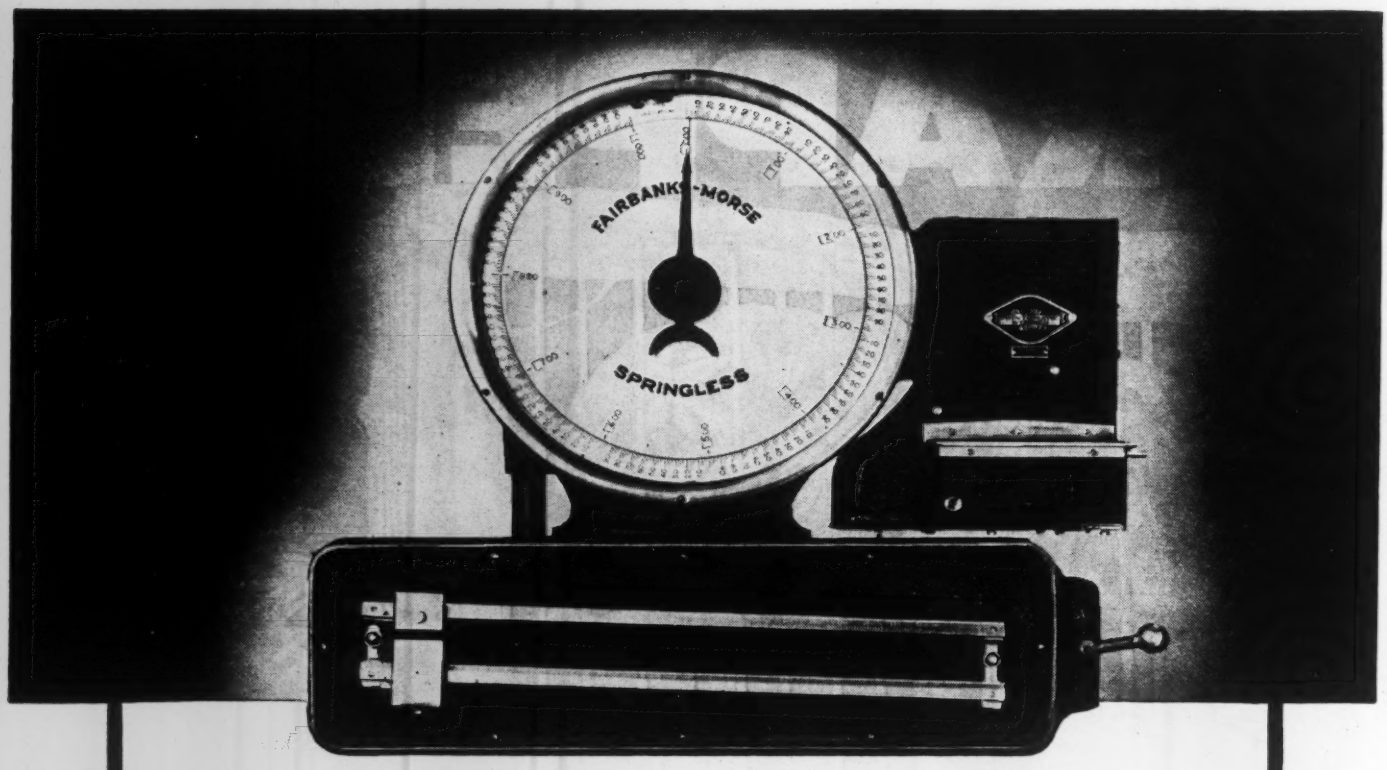


SAMPLES FOR ENGINEERS, DESIGNERS — We will gladly furnish Lisle Magnetic Plugs without charge to test in your products. No obligation. Tear out this ad and write today.

LISLE CORPORATION Box 1009 **Clarinda, Iowa**

Lisle Magnetic PLUGS

Fit right into your post-war plans!



A name worth remembering

FAIRBANKS-MORSE

Fairbanks-Morse is the name to think of first when you need scales. For 115 years Fairbanks-Morse Scales have met the varied and increasing needs of business. They have won the confidence of buyers and sellers . . . labor and management, because Fairbanks-Morse has always built accurate scales and is constantly working to improve them.

BUY AND HOLD MORE WAR BONDS

SCALES

FAIRBANKS, MORSE & CO.
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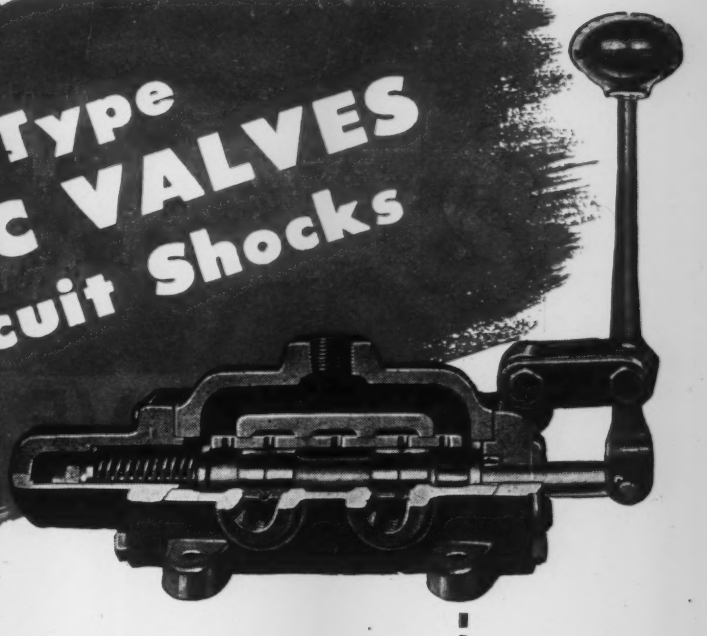
DIESEL LOCOMOTIVES • DIESEL ENGINES • GENERATORS • MOTORS • PUMPS • SCALES
MAGNETOS • STOKERS • RAILROAD MOTOR CARS and STANDPIPES • FARM EQUIPMENT

Sleeve Type HYDRAULIC VALVES Reduce Circuit Shocks

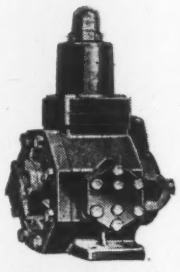


RACINE Oil Hydraulic Valves utilize a sleeve design. The full inner sleeve provides a continuous bearing and sealing area. Ports through this sleeve are clean drilled holes, permitting a gradual metering of the oil flow—thereby reducing circuit shock.

End caps and bodies are standardized and interchangeable. Sleeve construction permits a wide variety of porting arrangements. These features contribute to mass production and low costs to you.

RACINE'S complete valve line is designed for manual or remote solenoid and hydraulic controls. All standard iron pipe sizes from $\frac{3}{8}$" to 1-$\frac{1}{2}$" are available.

Consult our staff of field and factory hydraulic engineers. Ask them for a copy of Catalog P-10-C. At the same time, outline your hydraulic problems. Recommendations will be completed without cost to you.



"Variable Volume" Oil Hydraulic Pumps

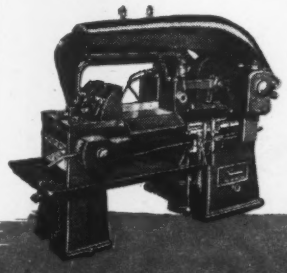
RACINE provides a complete series of "Variable Volume" Pumps. Capacities: 12, 20 and 30 G.P.M. Designed to operate at 50 to 1000 lbs. P.S.I.

For more than 15 years RACINE Hydraulic Units have been used on presses, die casting machines, drilling and wood working machinery, lifts, elevators and machine tools as well as other applications. Complete data supplied on request.

RACINE ECONOMIES

- ★ Balanced Piston-Sleeve Type construction—more efficient operation and longer valve life.
- ★ Sleeve permits various porting arrangements and internal modifications—fewer valves required.
- ★ Valve bodies and caps are interchangeable—easy to change without disturbing pipe connections—saves time, labor and equipment.
- ★ Valve mounting feet are integral with main valve body. End caps and gaskets do not absorb pipe line vibrations.

THE PRODUCTION SAWS OF MODERN INDUSTRY



A complete line of the most modern metal sawing machines. Simple, fool-proof operation and control devices for fast, accurate cutting of any metal. Capacities 6" x 6" to 20" x 20" in all price ranges. Ask for complete Catalog No. 12.
RACINE TOOL AND MACHINE COMPANY,
1776 State Street, Racine, Wis., U. S. A.

RACINE

STANDARD FOR QUALITY AND PRECISION
RACINE
RACINE TOOL and MACHINE CO.

LIGHT-MIGHT

TO SAVE WEIGHT TO GAIN STRENGTH

THINK OF STAMPINGS FIRST!

GREATER VALUES at lower cost! Mass production is the answer — stampings and stamped assemblies are essential in mass production.

UNDER POSTWAR CONDITIONS, every industry must face the fact that every economy in manufacture is imperative. When you plan a new product or an improved version of your present product consult with pressed metal experts in your vicinity before you begin designing.

FOR LOW COST per piece, for interchangeability, for minimum weight with maximum strength, for impact resistance, density, uniform appearance of high quality, whatever the metal — ***"Think of Stampings First!"***

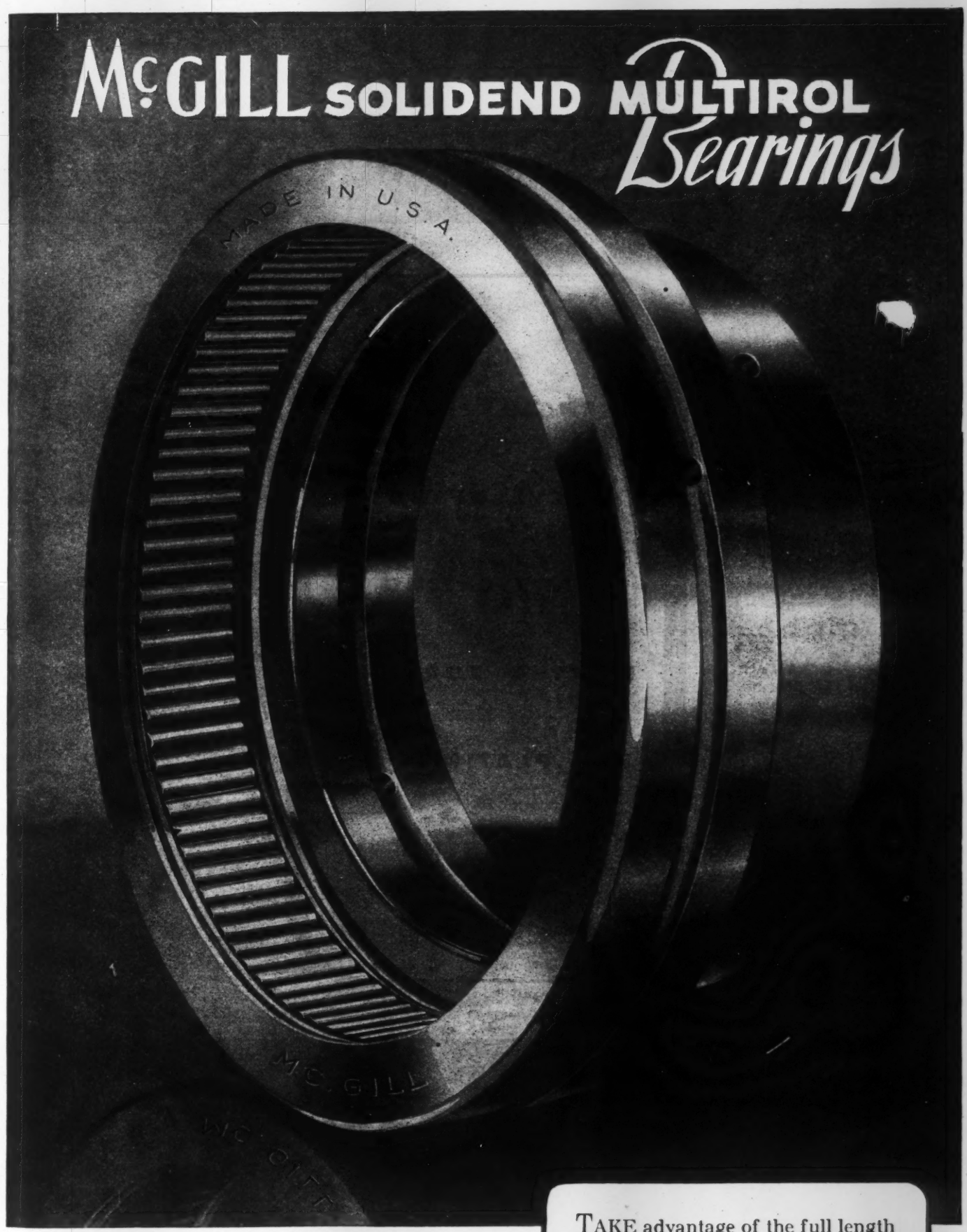
PMI

PRESSED METAL INSTITUTE

829 UNION COMMERCE BUILDING, CLEVELAND 14, OHIO

The Pressed Metal Institute is a nationwide association of leading pressed metal manufacturers, organized to advance the art and to assist other industries to take full advantage of latest stamping methods and techniques. If you are not affiliated and make stampings, write for particulars of membership today!

McGILL SOLIDEND MULTIROL Bearings



TAKE advantage of the full length rollers of McGILL "Solidend" *MULTIROL* Bearings. We will be glad to send you our catalog SM-42.

McGILL MANUFACTURING COMPANY, INC.

Manufacturers of Ball and Roller Bearings

VALPARAISO, INDIANA

METAL ASSEMBLIES AND COMPONENTS
FOR
ELECTRONIC AND MECHANICAL DEVICES

- ENGINEERING
- DEVELOPING
- FABRICATING
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- PLATING
- FINISHING

BERNARD RICE'S SONS
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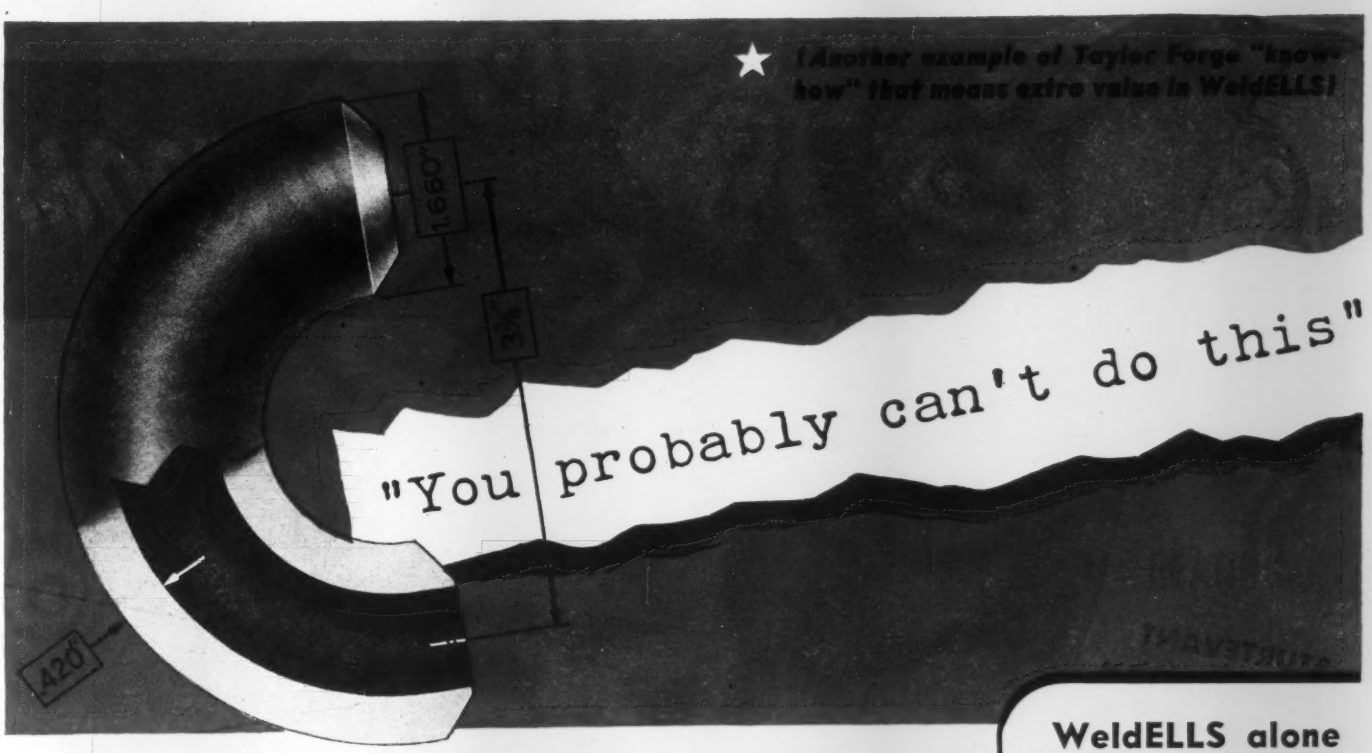
MANUFACTURERS OF QUALITY METAL PRODUCTS SINCE 1867

OFFICE: 325 FIFTH AVENUE, NEW YORK 16, N. Y.

WORKS: 139-145 NORTH TENTH STREET, BROOKLYN 11, N. Y.



....but we did!

★ *That, in effect, is what people occasionally have said when putting some tough specification before us . . . but if they were trying to stump someone they came to the wrong place!*

The fitting pictured above is a good example of this. As far as we know, no one else ever tried to forge a welding elbow or return bend having such great wall thickness in relation to the size of the fitting. There was good reason to doubt if it could be made, because such fittings simply couldn't be formed by the processes ordinarily employed in making welding fittings.

But special methods, developed by Taylor Forge, made this easy for us. It was another example of "You say it can't be done—but here it is!"

IN our standard, stock line of welding fittings, as in this special heavy wall return bend, you also find a combination of features that could not be achieved by the processes ordinarily employed in making welding fittings.

Take the selective reinforcement of the zone of highest stress in WeldELLS, for instance . . . or the tangents which help so much in lining up and welding . . . or the final truing operation which gives those extremely accurate dimensions.

These are features which eloquently attest to the "know-how" of Taylor Forge acquired in more than 40 years of handling just about every conceivable kind of forging problem in the piping field. Read the entire list of features opposite and we believe you will agree that

WeldELLS *have everything*

WeldELLS alone combine these features:

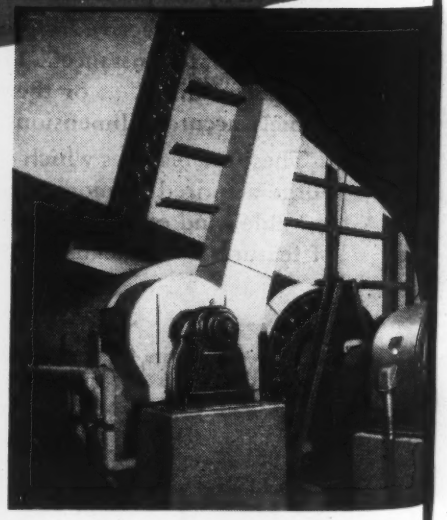
- **Seamless** — greater strength and uniformity.
- **Tangents**—keep weld away from zone of highest stress—simplify lining up.
- **Precision quarter-marked ends**—simplify layout and help insure accuracy.
- **Selective reinforcement** — provides uniform strength.
- **Permanent and complete identification marking**—saves time and eliminates errors in shop and field.
- **Wall thickness never less than specification minimum**—assures full strength and long life.
- **Machine tool beveled ends**—provides best welding surface and accurate bevel and land.
- **The most complete line of Welding Fittings and Forged Steel Flanges in the World** — insures complete service and undivided responsibility.

TAYLOR FORGE & PIPE WORKS, General Offices & Works: Chicago P.O. Box 485
New York Office: 50 Church Street • Philadelphia Office: Broad Street Station Bldg.

NO ROOM
STURTEVANT COMBINATION FLY-ASH COLLECTOR UNIT
Induced Draft Fan
Fly-Ash Collector
Volume Pressure Control
SPACE AVAILABLE FOR COLLECTOR AND I.D. FAN

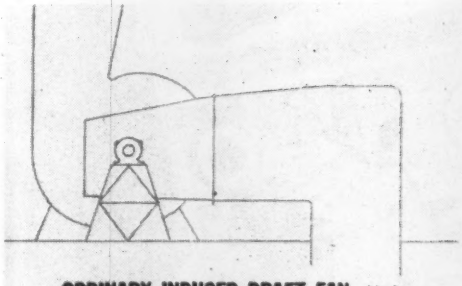
← When Fly Ash threatened to ruin their print rollers and other plant machinery, the U. S. Finishing Company, of Norwich, Conn., had no available space for the installation of a separate collector. Two of these Sturtevant S.A.I.D. fans solved the problem in practically the same space formerly occupied by the fans alone. Each handles 100,000 C.F.M. at 600 F. Westcott & Mapes, Inc., of New Haven, Conn., were the engineers.

Sturtevant S.A.I.D. Fan Unit with Vane → Control. Efficiency of Fly Ash Collector eliminates excessive erosion of induced draft fan—prevents dust nuisance around the plant.

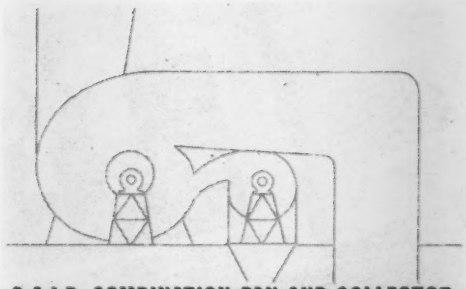


for Fly Ash Collectors?

Additional Space not needed with a Sturtevant S.A.I.D. System!



ORDINARY INDUCED DRAFT FAN—Major changes in power plant required to install independent collector.



S.A.I.D. COMBINATION FAN AND COLLECTOR May be installed in practically the same space required by ordinary induced draft fan.

Just imagine—here's complete fly-ash disposal equipment—induced draft fans, collectors and even vane control* for instant pressure regulation—and this complete unit takes up little more room than an I.D. fan alone! This outstanding Sturtevant engineering achievement makes possible the installation of fly-ash disposal equipment in many plants where limited available space rules out the conventional arrangement consisting of separate fans and collector units. See diagrams above.

With this Sturtevant "combination package" you get not only a spectacular saving in space—but also valuable savings in initial cost; greatly reduced maintenance, repair and replacement expense; and new standards of efficiency.

Write us for full information about this important step forward in fly-ash disposal equipment. On request a Sturtevant Engineer will gladly call on you and discuss your problem.

B. F. STURTEVANT COMPANY
Division of Westinghouse Electric
HYDE PARK, BOSTON 36, MASS.

*Reg. Trade Name, U. S. Patents 1,460,428; 1,578,843; 1,846,853; 1,989,413

AIR CONDITIONING

DRYING

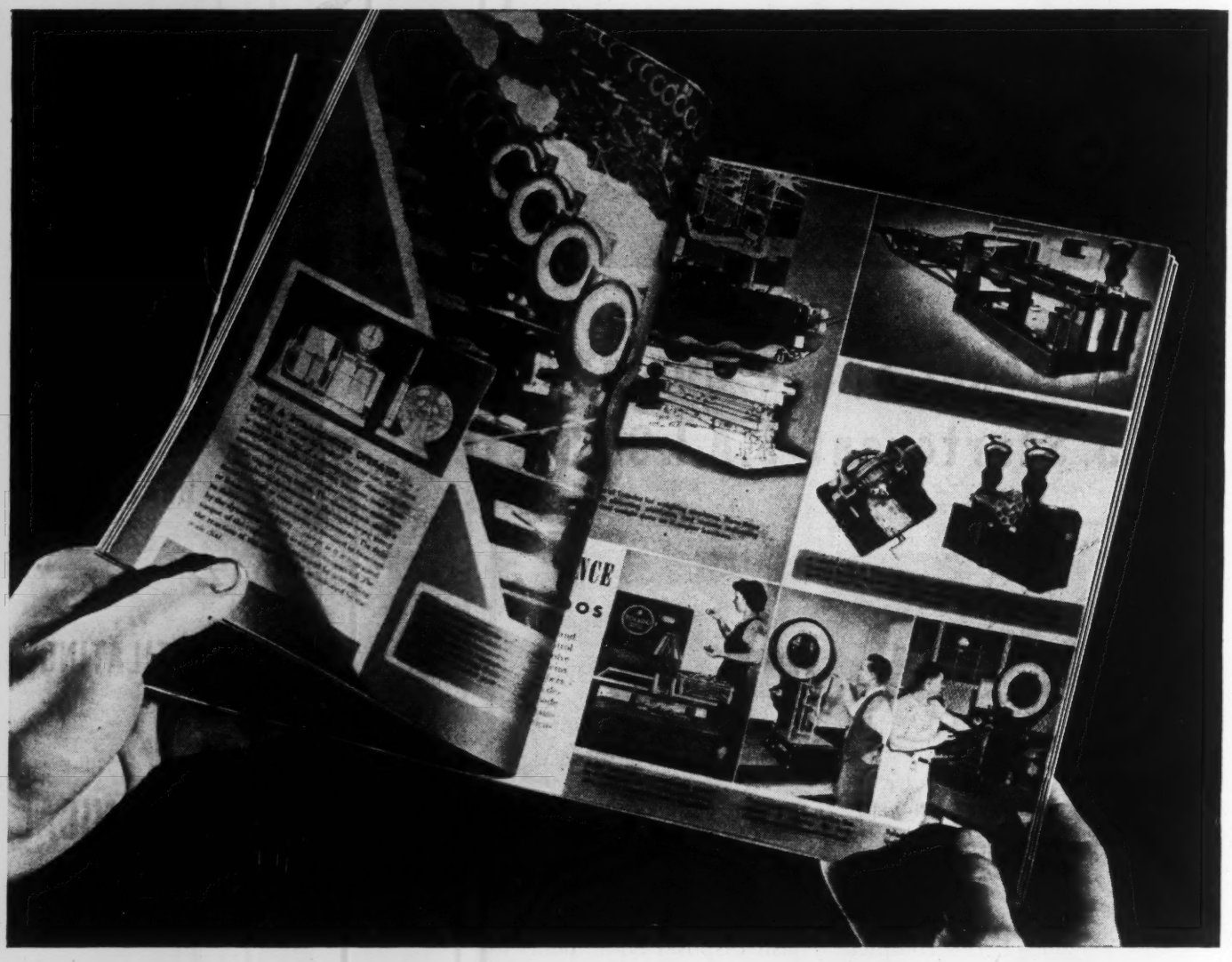
HEATING

VENTILATING

MECHANICAL DRAFT

DUST AND FUME CONTROL

Sturtevant
REG. U. S. PAT. OFF.
Puts Air to Work



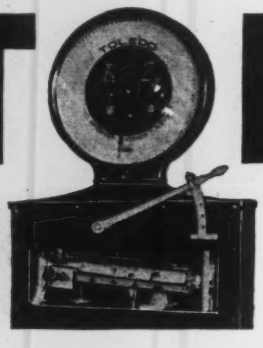
LOOKING AHEAD!

OUT OF WAR-PRODUCTION experience have come new production and control ideas. Many of them are readily adaptable to peace-production problems.

A GREAT MANY of these new developments in the general fields of weighing, testing, force-measuring, balancing, counting and batch-control can be seen in their war-applications, in the new booklet "Background for Victory". THIS IS NOT A POSTWAR CATALOG. It is an idea book for idea men looking for new ways to get better and faster results in these fields.

A COPY WILL BE SENT to any industrial executive, without charge, and without sales solicitation of any kind.

Toledo Scale Company, Toledo 12, Ohio.

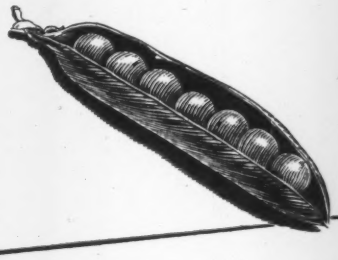


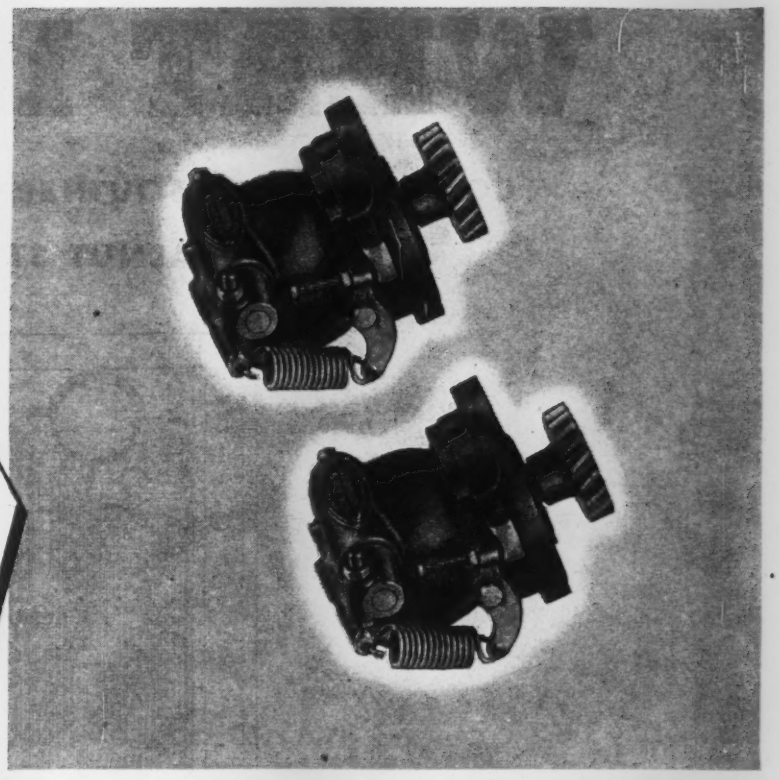
TOLEDO

HEADQUARTERS FOR ALL TYPES OF

SCALES

Two Peas in a Pod?





NO!

They're two different Governors built for two different purposes by the World's Largest Manufacturer of Governors

● Both of the governors pictured above fit the same engine. But one is engineered to govern that engine in the operation of a pumping unit, where a tolerance of 8 to 10% in regulation gives satisfactory performance.

The other unit is engineered to govern that engine in the operation of critical electrical apparatus, where a variation of *only one cycle* can be permitted.

Each provides the most economical governing for the specific purpose, both from the standpoint of initial investment and efficient operation.

Pierce has engineered over two thousand governor applications—each designed to do a special job on a specific piece of equipment. You can depend on Pierce to provide the right governor to do your exact job.

THE PIERCE GOVERNOR CO., INC. · 1657 Ohio Ave., Anderson, Ind.

Manufacturers of Pierce Precision Governors and Sisson Automatic Chokes

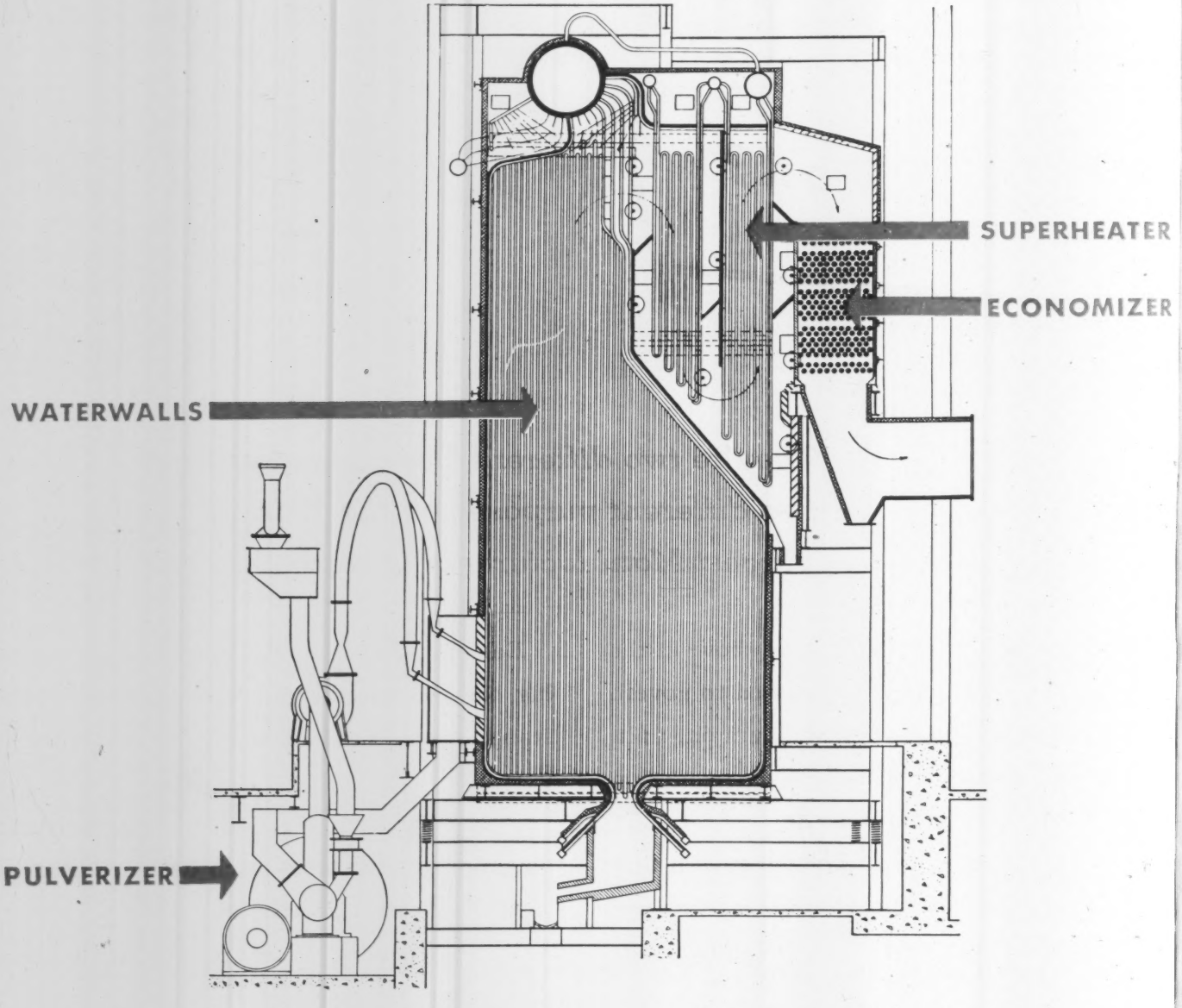
STANDARD EQUIPMENT ON MANY OF THE WORLD'S LEADING ENGINES!

PIERCE GOVERNORS

WHAT IS THIS

COLUMBUS AND SOUTHERN OHIO ELECTRIC CO.

WALNUT STATION



Maximum Load: 325,000 lb., steam per hour, 1400 lb., per sq. in. pressure, 900° F. final steam temperature

Foster Wheeler Corporation,

FOSTER

BOILER RATING?

The heating surface of this modern steam generator* is comprised of the following heat absorbing areas:

	Percent of total heating surface
SUPERHEATER	42.6
ECONOMIZER	37.2
WATERWALLS	20.2
BOILER TUBES	0

For 47 years Foster Wheeler has pioneered in the development of pulverized fuel systems and the three heat absorbing surfaces essential for modern central station steam generating units.

1898 **PULVERIZED FUEL** developed on a commercially successful scale.

1904 **SUPERHEATERS**—introduced the commercial use of superheated steam in the United States.

1919 **ECONOMIZERS**—introduced the forced circulation, high draft loss, counter-current, unit economizer.

1923 **WATER COOLED WALLS** for many types of furnaces burning various fuels.

*Exclusive of regenerative air heater

165 Broadway, New York, 6 N. Y.

WHEELER FW

INDUSTRY SPECIFIES

T-J CYLINDERS

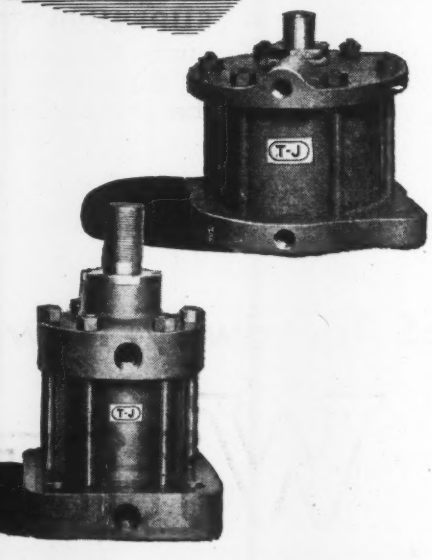
... FOR TOUGH JOBS IN POWER MOVEMENT

A T-J Cylinder has a vital job on this Pressure Contour Forming Machine! Used with various fixtures for producing contours in aircraft wings, fusilage, top body parts and similar structures.

FOR PUSH-PULL-LIFT JOBS...100 LB. OR 50,000 LB.

Today—more and more tough jobs in power movement throughout industry are geared to T-J Air and Hydraulic Cylinders!

Whether it's pushing, pulling, lifting, clamping or controlling... T-J Cylinders simplify the job and speed up production! Ideal for machines and equipment such as presses, hoists, shears, valves, brakes, hopper gates, ovens —or any place where efficient *controlled power movement* is needed. Many standard sizes and styles...both cushioned and non-cushioned types. Precision-manufactured to deliver smooth dependable power in every stroke —with utmost dependability and long life! Write for latest catalogs. The Tomkins-Johnson Company, 608 Mechanic Sreet, Jackson, Michigan.



FOR TOUGH JOBS SPECIFY T-J

TOMKINS-JOHNSON

RIVITORS...AIR AND HYDRAULIC CYLINDERS...CUTTERS...CLINCHORS

Sperry FOUND A BETTER WAY

TO HOLD MACHINE PARTS TOGETHER

WALDES TRUARC RETAINING RINGS

Before using Waldes Truarc Retaining Rings in Sperry gunsights, Sperry Gyroscope Co. engineers had difficulty with important taper pins working loose while the gunsights were in service. Due to vibration, pins occasionally loosened and fell out affecting the accuracy of the gunsights. Frequent, thorough inspection of taper pins in use didn't entirely solve the problem.

Then they specified Waldes Truarc Rings. Where taper pins had previously worked loose, the rings now held them fast. Assembly of the gunsights became much easier and quicker. Because of this earlier experience, Sperry used Waldes Truarc Rings as original equipment in their K-13 Compensating Gunsights. And Truarc *exceeded* their highest requirement for dependability in action.

Waldes Truarc Retaining Rings are used to save weight, space, cost and man-hours in a wide range of products. For holding and positioning machine parts they offer definite advantages over nuts, shoulders, collars, and pins. They simplify and speed up production. They can be put on and taken off again and again —and still retain the perfect circularity which gives them their unfailing grip. Test them yourself. We'll furnish samples and complete data. Write Dept. P-12.

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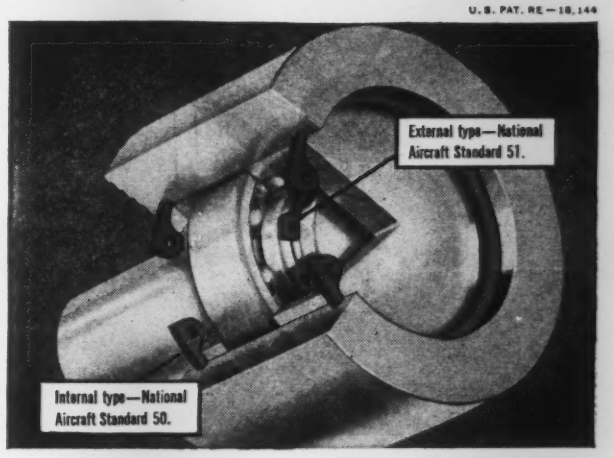


WALDES TRUARC TRADE MARK **RETAINING RINGS**

WALDES KOHINOOR, INC., LONG ISLAND CITY 1, NEW YORK

CANADIAN REPRESENTATIVES: PRENCO PROGRESS CORP., LTD., 72-74 STAFFORD ST., TORONTO

If you use hoisting equipment, you need the

SAFETY CODE for CRANES, DERRICKS, and HOISTS

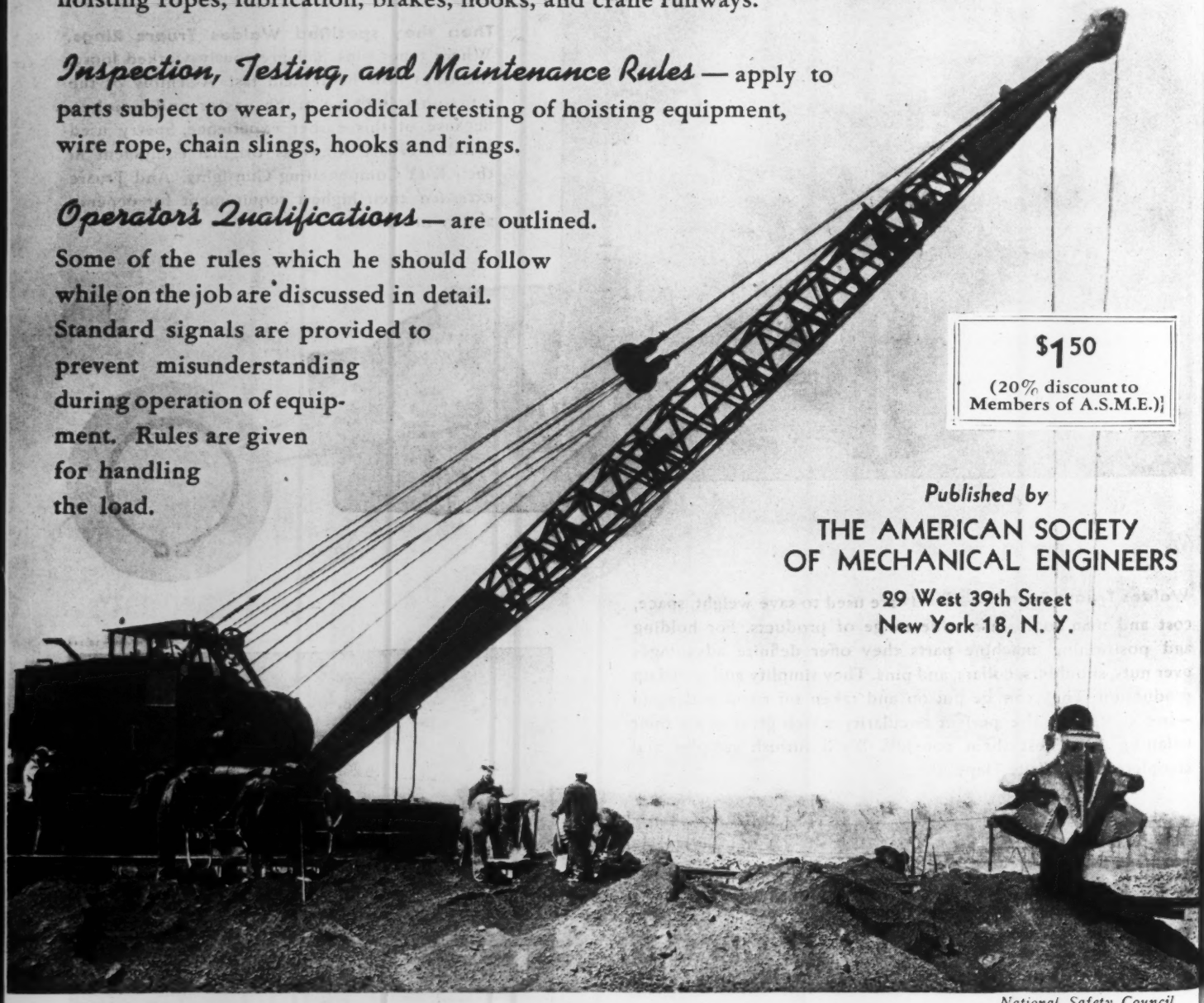
Published January, 1943

This Nationally Recognized Standard — covers cranes and derricks driven by steam engines, electric motors, or internal combustion engines, as well as their runways. It also applies to simple drum hoists of whatever motive power, to overhead air hoists, and to hand-powered derricks.

Construction Details — are provided for each type of crane and hoist; for cages, electric equipment, catwalks and ladders for the types of cranes on which they are used. In addition, there are requirements for mechanical guarding of moving parts and hoisting ropes, lubrication, brakes, hooks, and crane runways.

Inspection, Testing, and Maintenance Rules — apply to parts subject to wear, periodical retesting of hoisting equipment, wire rope, chain slings, hooks and rings.

Operator's Qualifications — are outlined. Some of the rules which he should follow while on the job are discussed in detail. Standard signals are provided to prevent misunderstanding during operation of equipment. Rules are given for handling the load.



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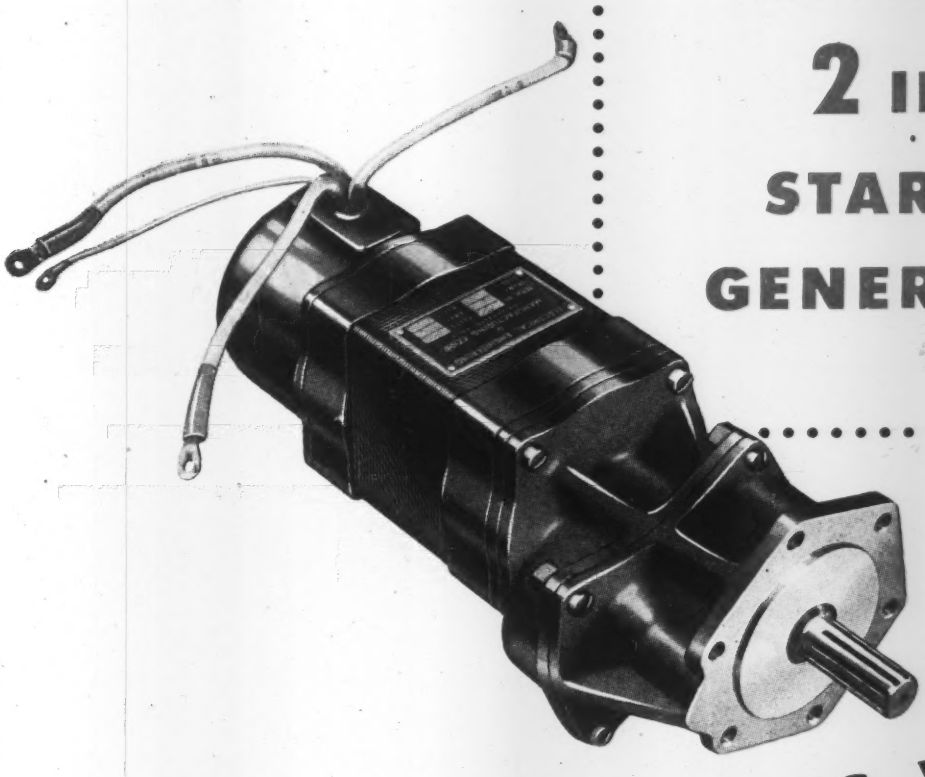
DIRECT-CONNECTED

2 IN 1 STARTER GENERATOR



SAVES GEARING

SAVES WEIGHT

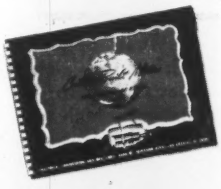
. . . INCREASES AIRCRAFT PAY LOADS

Here's another EEMCO special design. Separate gear-driven generators and starters can now be replaced by one *single-unit, direct-drive* starter-generator that weighs only 19 pounds. An EEMCO starter-generator on an aircraft engine can save up to 20 pounds of weight. This means more gasoline (extending cruising range) or more baggage can be carried. In addition, wiring and servicing is simplified and space is conserved through the 2-in-1 design.

These sturdy units are built for long service. They have plenty of torque for starting four-cylinder engines up to 125 hp. This same torque will start even larger six- and eight-cylinder engines. As generators, they deliver 500 watts, continuous duty. A torque-limiting device built into the unit protects against damage from engine backfire. The direct connection to the engine crankshaft eliminates need for gear drives.

TECHNICAL DATA

Rated at 500 watts, for 12-, 24-, or 32-volt systems, at 50° temp. rise. Maximum starting torque is 160 foot pounds. Two gear reductions incorporated in unit: 23:1 for cranking; 2½:1 for generating. Torque-limiting clutch built in. Can be fitted to most engines through available adapter mounting brackets.



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ELECTRICAL ENGINEERING AND MFG. CORP.
4606 West Jefferson Boulevard, Los Angeles 16, California

EEMCo

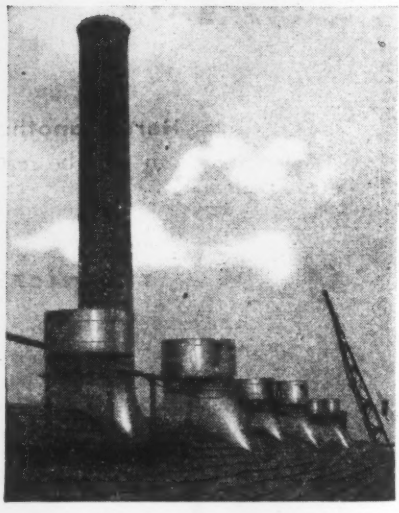
Keeping the Braiding Room Cool
at General Cable Corporation

Perhaps you don't think of cable braiding as *hot* work. Normally it isn't. But when you have *hundreds* of braiding machines in one large room, as they are at General Cable Corporation, it takes excellent ventilation to dissipate the frictional heat that would make working environment almost intolerable. At General Cable's Perth Amboy plant, Propellair airfoil fans provide positive air movement for *continuous circulation* to keep workers comfortable even in the hottest, humid summer months.

In all, there are 24 Propellair wall-type fans and 12 Propellair Verti-Stacks (Power Roof Ventilators) serving various ventilating functions. In the Braiding Room these two types of installations supplement each other, the wall fans drawing in large volumes of *cool,* fresh air while the powerful suction of roof exhausts expels heated air *immediately.* As the above photograph shows, wall fans are installed in window openings, and set on an angle so that blasts of outside air are directly upon the machines.

The Braiding Room installation has been in operation for over two years on a 24-hour-a-day schedule, *seven days a week,* without any servicing whatever except normal maintenance. Other Propellair fans, which exhaust noxious fumes from dip tanks, have been in use for four years with the same low maintenance record.

Propellair fans don't *fan the air,* they *move* it—and with *minimum* h.p. for *maximum* c.f.m. Types and sizes for every industrial service. Distributors in 25 principal cities. Ask us today for free 72-page Catalog No. 10-ME.



A few of the Propellair Verti-Stacks at General Cable. They open automatically when fan is started; close completely as fan coasts to a stop; offer virtually zero resistance to high velocity air passage. All Propellair fans have scientific airfoil-section blades with variations of pitch, curvature, and *thickness* to compensate for the different speeds of points at various radii. The *whole blade* works —not just the *tip*.

PROPELLAIR, Inc. "Moving Air is our Business" SPRINGFIELD · OHIO

Engineered and Proved Construction

1. FORGED STEEL CASE—Supported at the center-line to prevent distortion caused by changes in temperature—vertically split with ring type joints to assure tightness under all pressures and temperatures. May be lined with corrosion resistant material when necessary.

2. REMOVABLE END COVERS—Of forged steel.

3. DEEP WATER-COOLED STUFFING BOXES—With renewable throats—reduce wear and prolong life of packing.

4. PACIFIC PATENTED FLOATING SEAL—Hydraulically balanced—non-seizing—balances lateral thrust of rotating element and reduces pressure on discharge stuffing box to suction pressure.

5. DIFFUSERS—Efficiently convert velocity energy to pressure energy—assure perfect radial balance.

6. POSITIVE STAGE-TO-STAGE SEAL—Seals face-to-face and metal-to-metal—all interior gaskets eliminated.

7. PRESSURE LUBRICATION—Provided for all bearings by oil pump driven from pump shaft.

8. PACIFIC TYPE I CENTRIFUGAL PUMP—May be dismantled and re-assembled without breaking suction and discharge connections. The rotor may be completely assembled outside of pump shell.

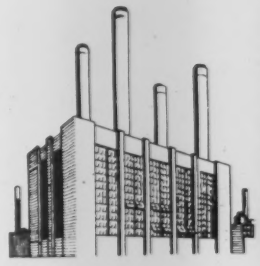
RATING—Designed for speeds up to 3600 R.P.M.

Sizes—2 to 8 inches.

Capacities—75 to 2700 G.P.M.

Differential Pressures—up to 2500 lbs.

Operating Temperatures—up to 800° F.



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PACIFIC PUMPS INC., Huntington Park, Calif.

One of the Dresser Industries

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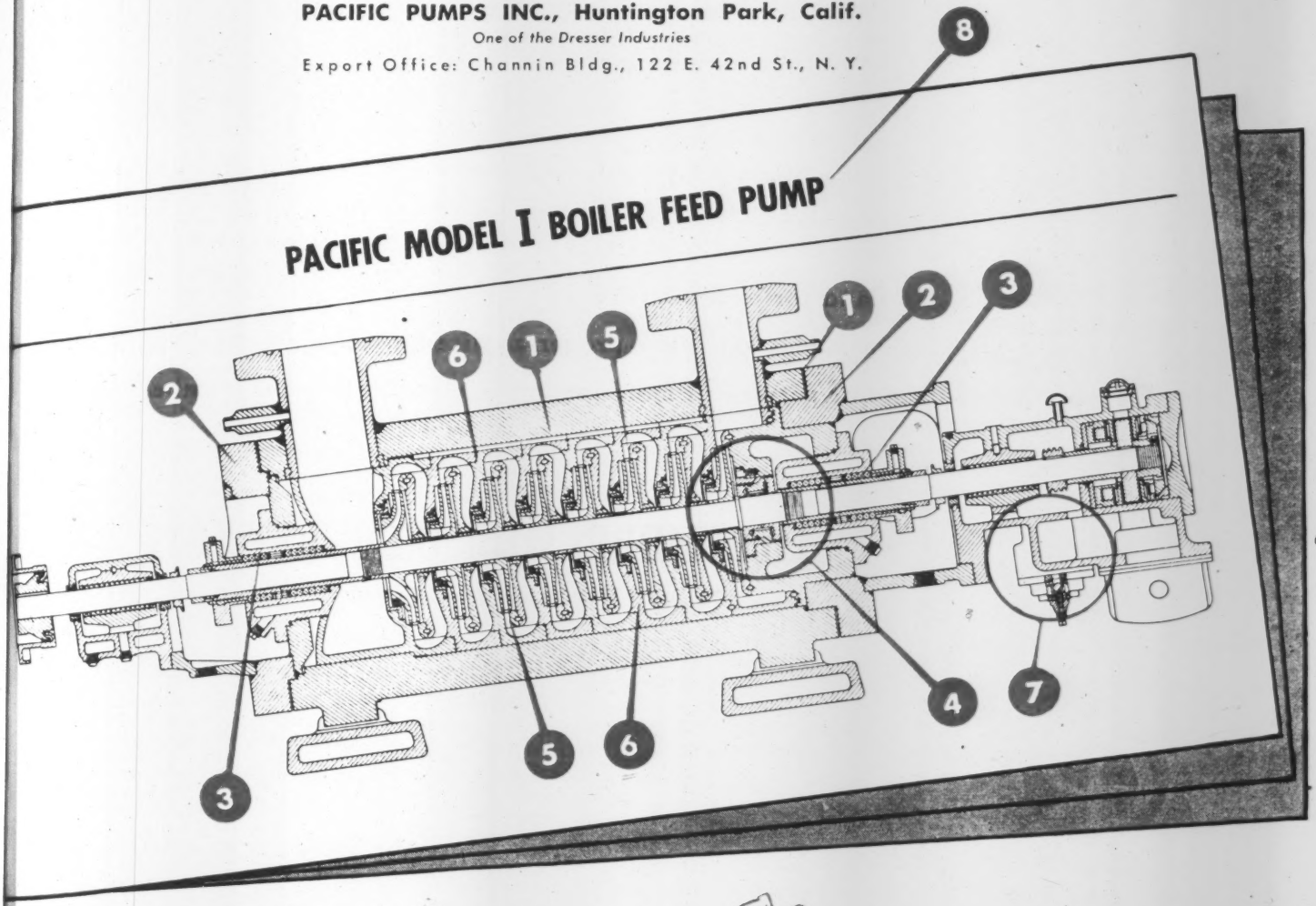

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Forgings Provide ADDED STRENGTH where it is needed most

The invaluable added strength that is imparted by forging to both the machine as a whole and to the desired sections of forged parts, cannot be secured by any other process.

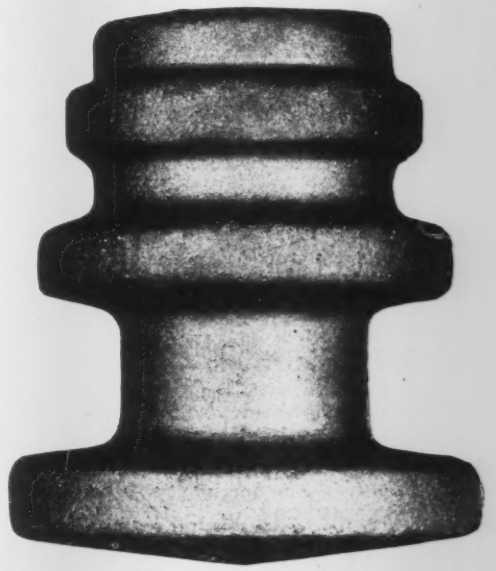
The high-speed, heavy duty machines of today require steel at its ultimate strength to assure safe, dependable, trouble-free operation. Maximum metal quality is attained in forgings; especially for these parts which are subjected to tensional, torsional and compression stresses. The superior fatigue resistance of forgings, retained to a high degree after repeated stresses, enhances the useful life of the machine in which they are employed.

In many machine parts, some sections are subjected to greater shock and stress than others. Naturally then, it has become common practice for users of forgings to specify the directioning of the grain flow to meet the shock and stress recurring under actual service conditions. Proper designing of dies and modern day forging practice make it possible to develop the grain flow in the desired directions, as shown in the micro-views herewith. With controlled grain flow, the metal is compacted into a dense mass of high strength and toughness at the critical points. This characteristic, obtainable only in forgings, is of special value in parts subjected to fluctuating or reversing loads, impact or similar working stresses.

The engineering department of Kropp Forge Company will gladly consult with machine designers on stress problems.

Whenever you need flat die, drop or upset forgings, call your nearest Kropp engineering representative or send your prints direct for immediate quotation.

The fiber flow lines indicate the added strength at points of greatest shock and stress obtained in the forging shown below.



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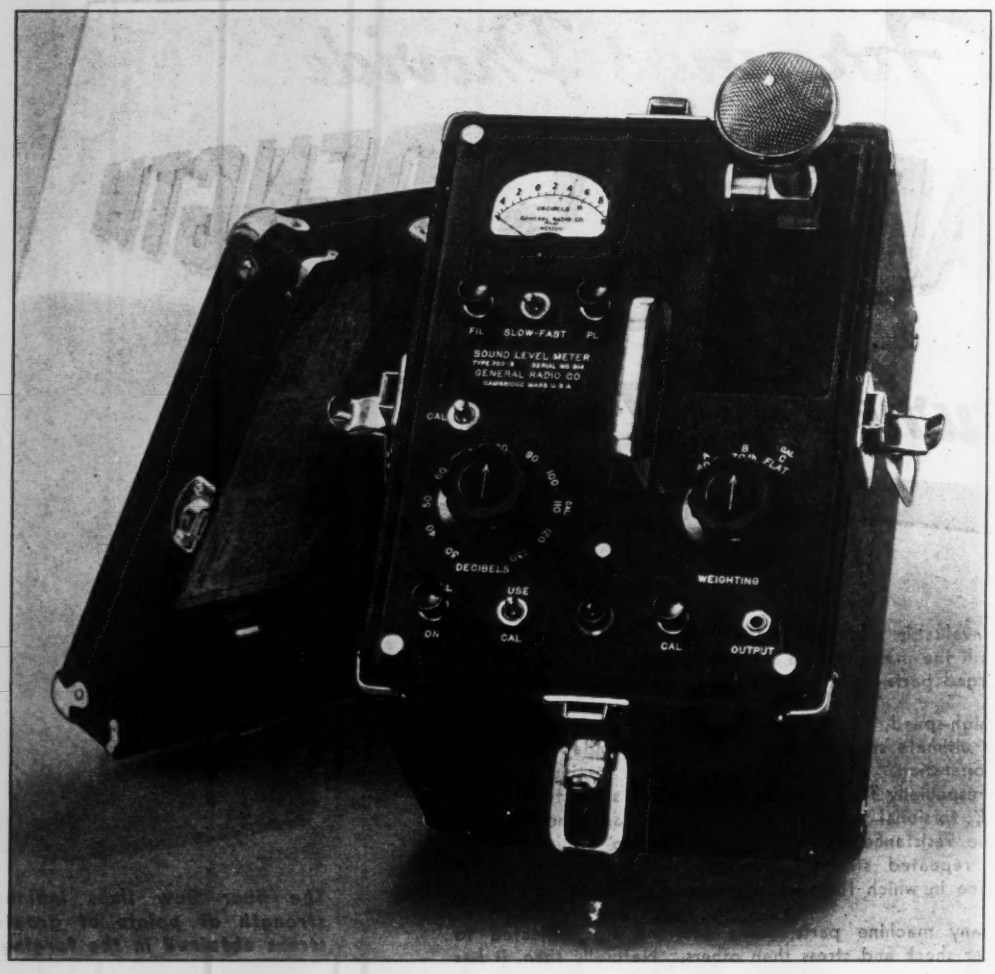
"FORGINGS TO EVERY SPECIFICATION"

SOUND MEASUREMENTS are EASY



WITH THIS ACCURATE, RUGGED, PORTABLE METER

● The General Radio Sound Level Meter makes possible the measurement of intensity of sound conveniently, quickly and accurately by anyone. This instrument is widely used throughout industry for all types of noise measurement and study. It is completely self-contained and portable, and will measure the volume of noise from a whisper to a locomotive whistle.

FEATURES

1 EXCEPTIONALLY WIDE RANGE—24 to 140 decibels

2 SIMPLE CONTROLS—complete db range is covered by a single control knob

3 IMPROVED MICROPHONE—crystal, diaphragm, type of great sensitivity, very rugged, and unaffected by ordinary changes in temperature and humidity

4 PLUG-IN MICROPHONE—normally used directly on folding socket on instrument, but can be detached and used with cable and tripod for special applications

5 SLOW-FAST METER—control switch selects either movement; "fast" position corresponds to A.S.A. tentative standards; on "slow" position the meter is heavily damped to measure the average level of rapid fluctuations

6 INTERNAL CALIBRATION SYSTEM—calibration can be checked quickly at any time from built-in calibrator

7 THREE WEIGHTING NETWORKS—low level, high level and substantially flat over-all response

8 NO COILS—instrument contains no coils or inductances and accordingly gives accurate readings in the presence of any ordinary magnetic field

TYPE 759-B SOUND LEVEL METER.....$195

WRITE FOR BULLETIN 978 FOR COMPLETE INFORMATION

GENERAL RADIO COMPANY Cambridge 39, Massachusetts

90 West St., New York 6 920 S. Michigan Ave., Chicago 5 1000 N. Seward St., Los Angeles 38

partners in creating

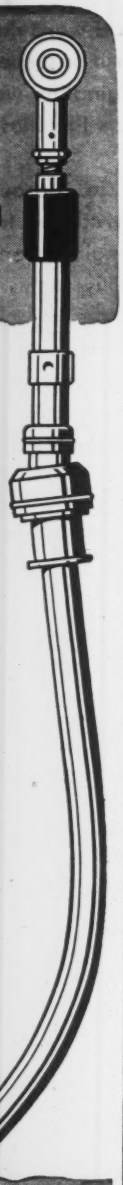
"Impossible" is a word that is not recognized by engineers. To dam a mighty river, tunnel under it or suspend a bridge across it—things such as these that once seemed pure imagination were made possible by instruments devised to refine and extend human faculties, to translate the precision of engineering thought into action.

Keuffel & Esser Co. is proud to have played so large a part in making such instruments widely available. In this way K & E equipment and materials have been partners of the engineer and draftsman for 78 years in shaping the modern world. So universally is this equipment used, it is self-evident that K & E have played a part in the completion of nearly every engineering project of any magnitude. Could you wish any surer guidance than this in the selection of your own "partners in creating"?

Not only for construction and building, but for setting up precision machine tools and long production lines, in the fabrication of large ships and aircraft, experienced engineers know that they can rely utterly on K & E transits and levels. Coated lenses for increased light transmission, precision-ground adjusting screws, chromium-coated inner center and draw tubes, completely enclosed leveling screws, improved achromatic telescopes—all these typify the advanced design of these instruments.

SIMMONDS PRECISION-BUILT

PUSH-PULL CONTROLS



Solve problems in . . .

PRECISION DETOURS VIBRATION

Are you taking advantage of the most advanced design methods in handling your remote control problems?

Simmonds Push-Pull Controls, developed to meet exacting aircraft standards, are being increasingly specified by industrial engineers in many fields. More than half a million Simmonds controls are today giving rugged, trouble-free service in installations that require the ultimate in accuracy—eliminating awkward pulley-and-cable and rod-and-bellcrank set-ups. Especially successful in solving problems involving vibration and difficult contours. A wide variety of accessories and fittings make Simmonds controls adaptable to many purposes.

Let Simmonds engineers help solve your remote control problems. There is no obligation.

Send Your Control Problems to Simmonds Control Headquarters

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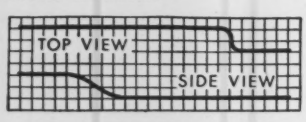
Simmonds PRODUCTS INC.

Let Simmonds Analyze Your Control Problem

Simply submit the basic requirements, as follows:

- **What does the control operate?**
- **LOAD: Compression (lbs.) Tension (lbs.)**
- **VIBRATION CHARACTERISTICS**
- **TEMPERATURE CONDITIONS**
- **PRESENT SYSTEM**
- **FLEXIBLE OR RIGID HOUSING?**

Make sketches of top and side views of installation. Use regular graph paper and indicate unit of measure.



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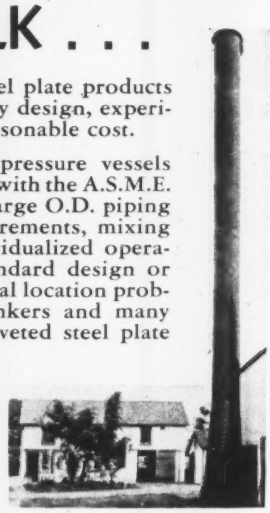
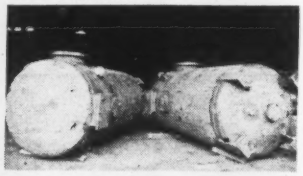
LANCASTER can furnish pressure vessels manufactured in accordance with the A.S.M.E. Code or API-ASME Code, large O.D. piping to fit your specialized requirements, mixing and process tanks for individualized operations, elevated tanks to standard design or constructed to meet an unusual location problem, storage bins, coal bunkers and many other types of welded or riveted steel plate products.



If you have a storage problem it will be to your advantage to consult LANCASTER'S engineers. Complete designs and estimates will be furnished promptly after receipt of your inquiry, with no obligation on your part.



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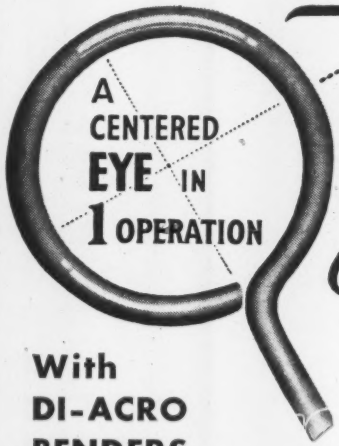
Lancaster, Penna.



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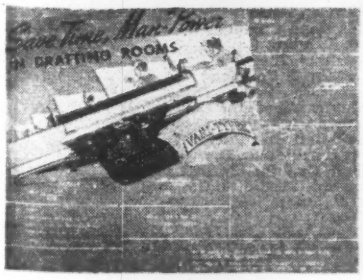

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The knurled head provides a slip-proof grip . . . even for oily fingers. No useless twisting, and turning

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Can be screwed-in farther—*faster* before using a wrench

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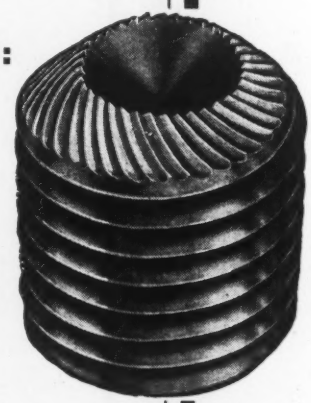

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Won't be shaken loose by any amount of vibration . . . instead the knurls dig-in *against* vibration—hold firmly

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Both screws in sizes from #0 to 1½" in diameter—full range of lengths

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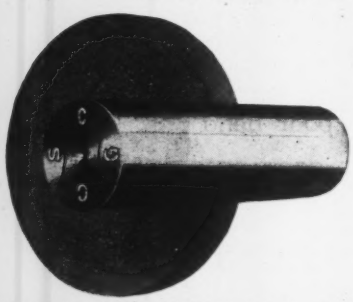

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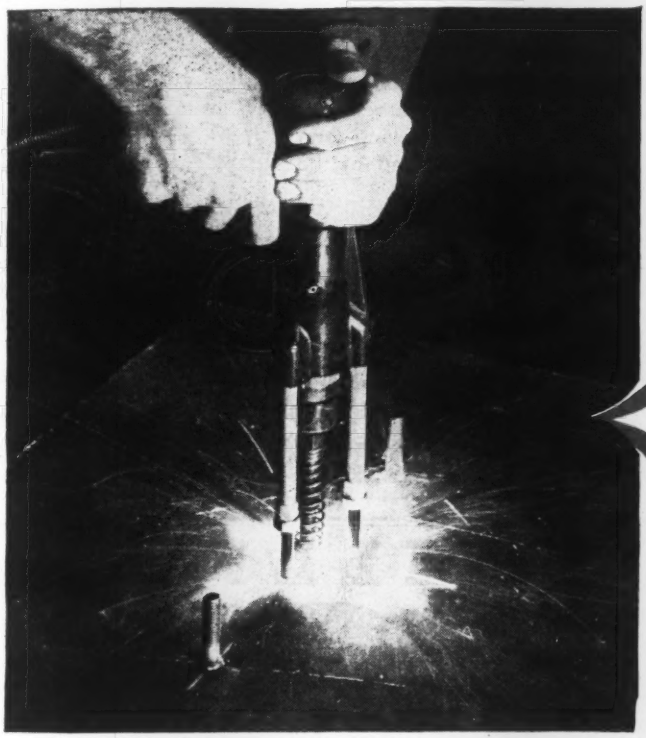
6 ways to fasten metal parts in ½ second with NELSON *automatic* STUD WELDING



The NELSON Stud Welder is fully portable, works from any standard welding generator, and welds in any position. Studs from ⅛" to ¾" in diameter and up to 8" in length are welded with complete fusion to metal in ½ second.
To speed production, to do a *better* job faster, put this versatile tool on *your* job. The facts are yours for the asking . . .

WRITE NOW for complete information, or to arrange a demonstration in your own shop at your convenience . . .

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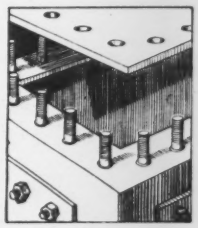
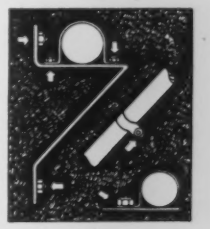


Securing Covers: Covers of all kinds, with or without gaskets, can be secured quickly and easily. Usually the cover itself can be used as a template; studs are welded through the cover holes.

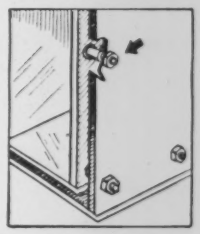
Pipe Hangers and Brackets: There are scores of faster, better ways to secure pipe, tubing or conduit with stud welding. Welds can be made in all positions; welder is completely portable.

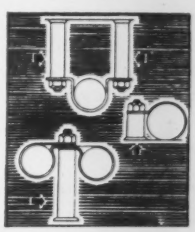


General Fastening to Metal: Wherever brackets or attachments must be secured to sheet, plate or structural metal, the stud welder can do the job at the rate of one-half second or less per weed.

SHOULDER STUDS

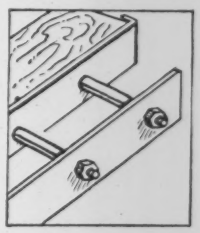
Metal Liners and Jackets: The shoulder stud provides correct spacing between liner and casing or jacket, and no holes pass through the liner which can be left smooth and unblemished.



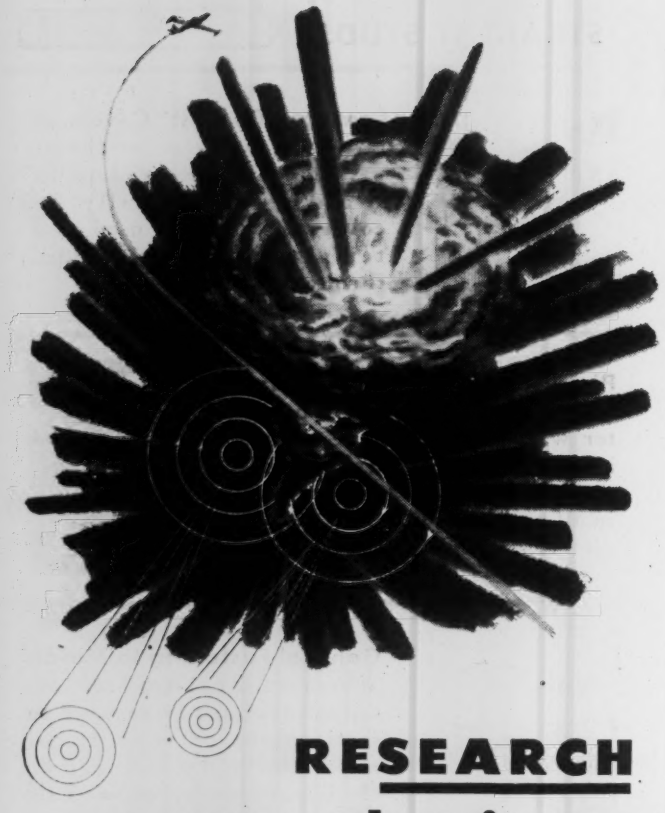


Securing Pipe, Cable and Hose: Shoulder studs provide a fast, convenient method of attaching many types of pipe, conduit, cable, tubing or hose; three typical applications are illustrated at left.

Spacer and Bumper Bars: Spacer bars, bumpers and guard rails can be attached simply and economically with shoulder studs. Portability of the stud welder makes the job easy on large assemblies.



OTHER NELSON FLUX-FILLED STUDS



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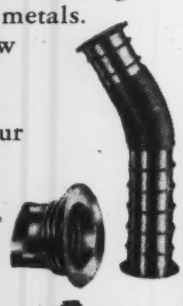

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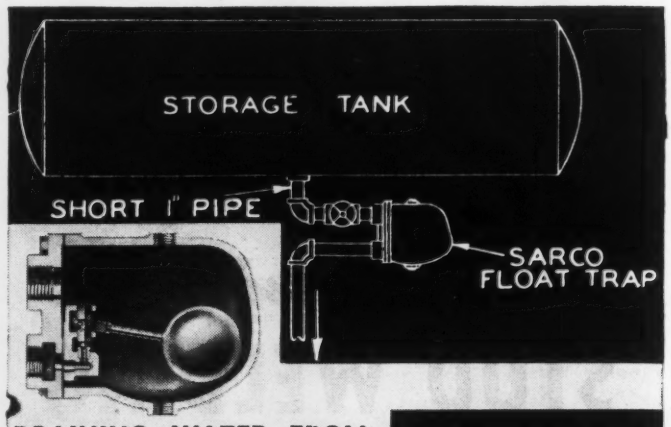

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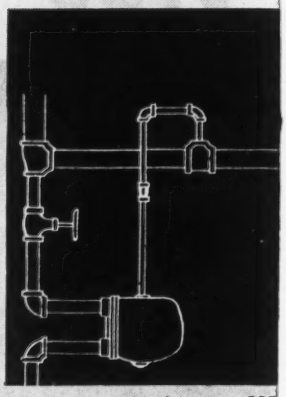

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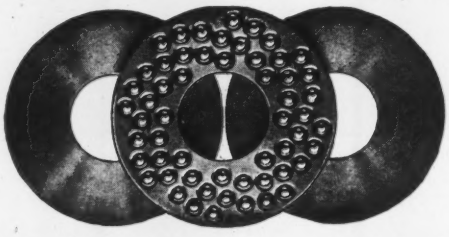

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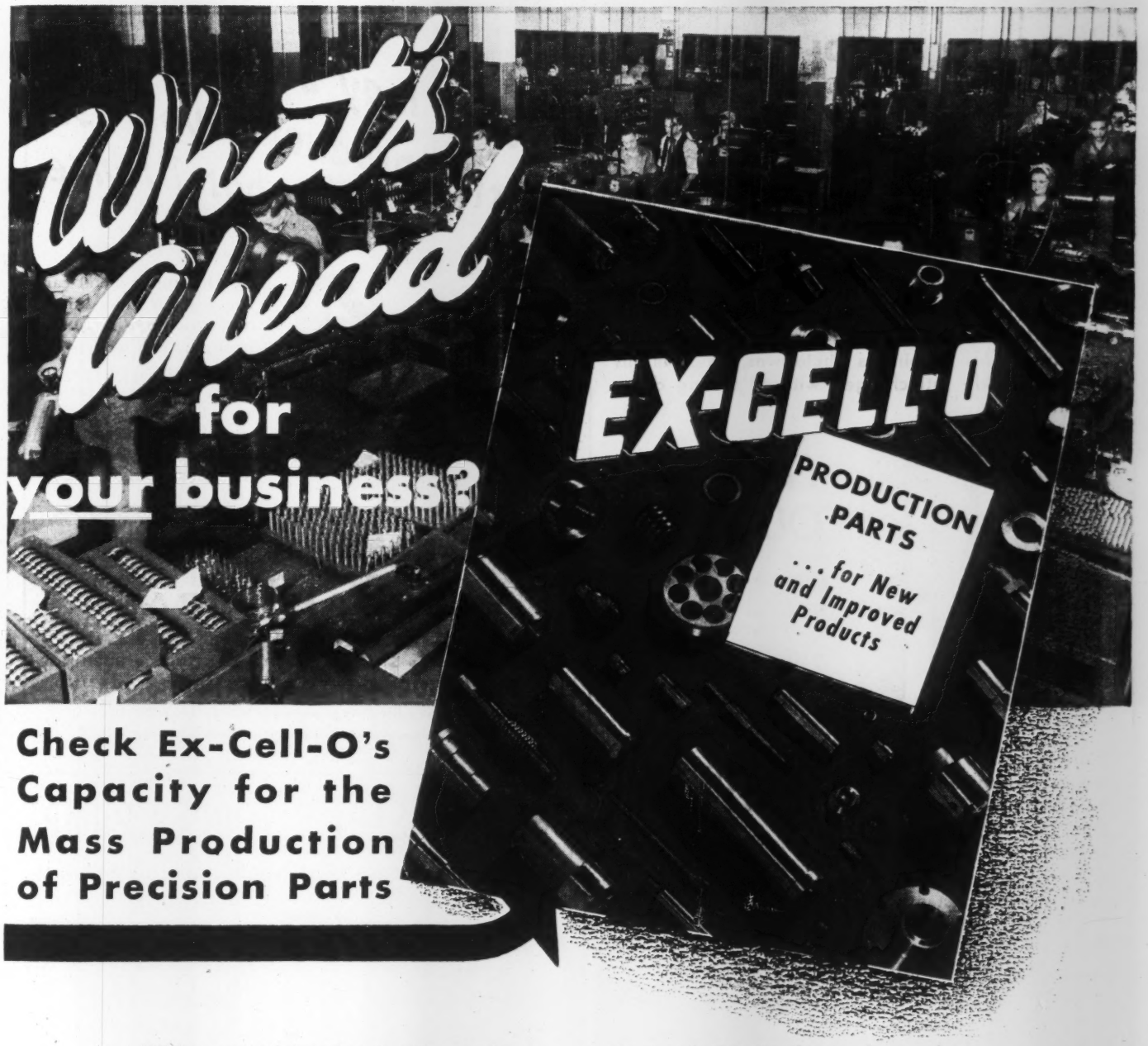

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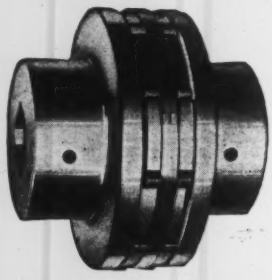

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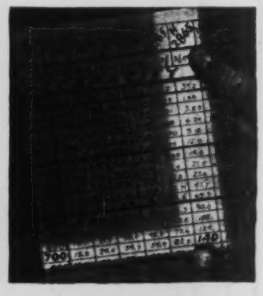
There's an L-R for every requirement from 1/6 to 2500 H.P.



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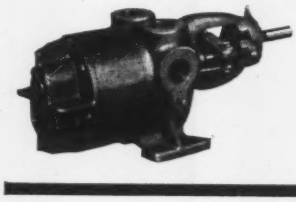

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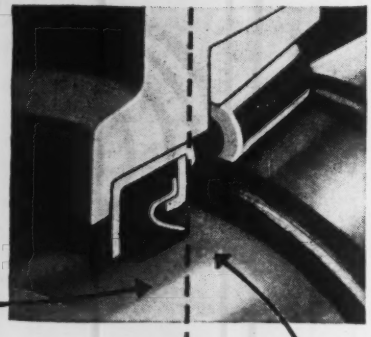

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KEEP OIL AND GREASE IN

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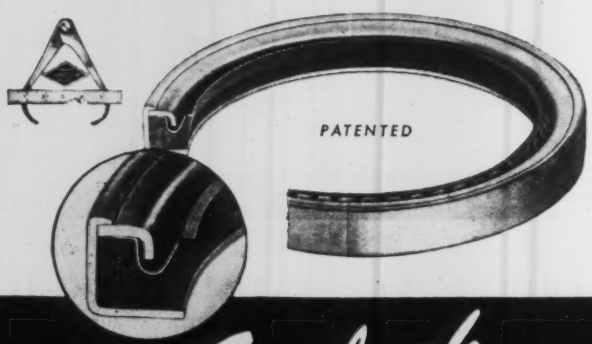
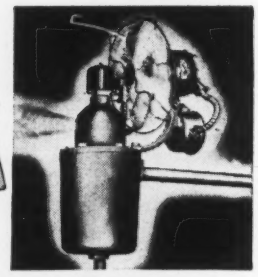


The Garlock KLOZURE OIL SEAL



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Send for bulletin 158 for complete information.

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894 Maple Street Three Rivers, Michigan

ARMSTRONG *Steam Type* UNIT HUMIDIFIERS

Straight Talk from Santa!

"This year, more than ever before, I hope every package on my sled is festooned with Christmas Seals!

"I figure that makes it a double gift —a gift to all mankind. You see, *those seals save lives* — make possible a year-round program against tuberculosis.

"The need this year is greater than ever before. So that's why I say *make every package and letter count*. And—be sure to send in your contribution!

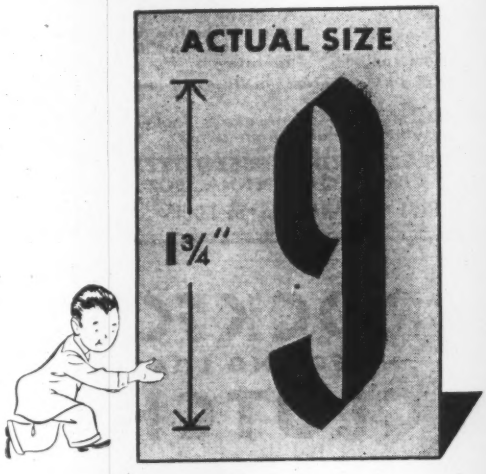
"Merry Christmas!"

BUY CHRISTMAS SEALS

Because of the importance of the above message, this space has been contributed by

MECHANICAL ENGINEERING

YOUR 1946 CALENDAR IS READY



...with **GIANT SIZE** dates

Each numeral 1¾" high—that's the feature of this beautiful new six-color POST 1946 Calendar—overall size 12"x20". Each date of the week is designed to be legible from any spot in the drafting room. The entire current month with ultimate and proximate months appear on each weekly page. The calendar is in full, brilliant color and includes a section devoted to significant drafting room data, covering charts on wire and sheet metal gages, screw threads, bolt heads, pipe and pipe fittings, gears, metric equivalent, and complete twelve-month calendar.

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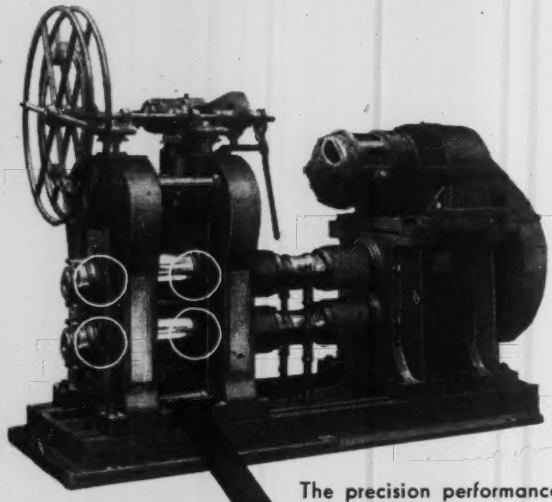
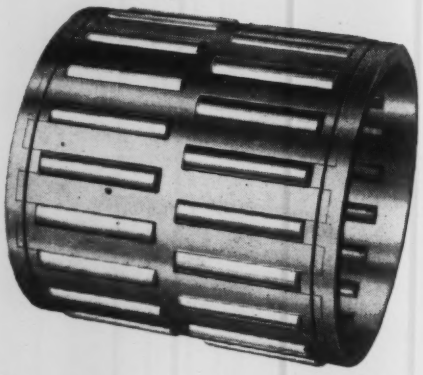


The precision performance of "Standard" Rolling Mills for high production, hot or cold rolling of strip, rod and ingot, depends on the supreme accuracy of "Standard" Bearings.



"Standard" Bearings are proving their worth in Panama Canal locks, submarine deck guns, heavy cranes, huge printing presses, etc., by providing longest service and lowest maintenance. "Standard" Bearings are available in either ball or roll type, designed for light or heaviest duties in sizes from 6" to 65" diameter to meet your specific requirements.

Let us know your needs

STANDARD MACHINERY COMPANY

1546 Elmwood Ave., Providence 7, R. I.

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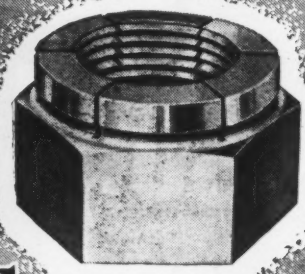

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Pat'd & Pat's Pend.

Search no more . . . This all-metal one-piece "Flexloc" Stop and Lock Nut has every desirable feature. Just look them over:

√ It is of one-piece construction
√ It can be made of any of the conventional nut materials
√ Every thread—including locking threads—takes its share of the load
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Sizes from #6 to 1" in diameter; millions in use. Write for Bulletin 582.

The famous "Unbrako" Socket Screw Products are also made by us.

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Specify ROCKFORD —SPRING LOADED— for CLUTCHES

LIGHT PEDAL PRESSURE
CUSHIONED ENGAGEMENT *
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ACCURATE BALANCE
DIRT EXCLUSION
HEAT DISSIPATION
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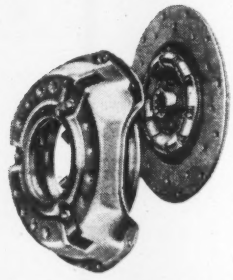


* The cushioning spring arrangement between the facings in ROCKFORD Spring Loaded CLUTCHES provides cushioned engagement that enables smooth pick-up of the load, without grabbing or chattering. The springs maintain ample pressure to assure the required torque.

SEND FOR THIS HANDY BULLETIN ON POWER TRANSMISSION

It shows typical installations of ROCKFORD CLUTCHES and POWER TAKE-OFFS Contains diagrams of unique applications. Furnishes capacitity tables, dimensions and complete specifications. Every production engineer will find help in this handy bulletin, when planning postwar products.

ROCKFORD CLUTCH (FORMERLY KNOWN AS DRILLING MACHINE) **DIVISION** BORG-WARNER CORPORATION

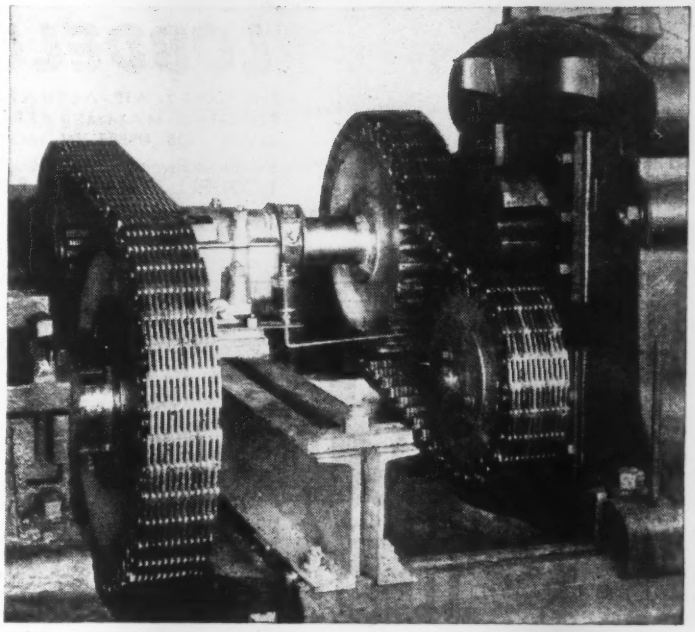
1307 Eighteenth Avenue, Rockford, Illinois, U. S. A.

ROCKFORD CLUTCHES

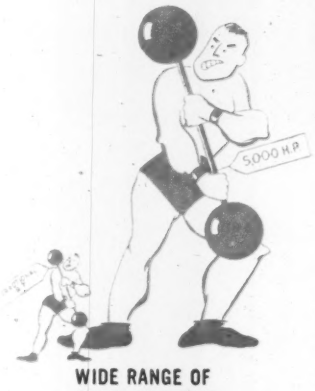
Just to Remind You...

FULL CAPACITY

POWER SAVING



EASY TO MAINTAIN



WIDE RANGE OF SIZES AVAILABLE

Countless applications in a multitude of industries have proved Morse roller and silent chain efficiency. A wide range of sizes is available. Each in its field has demonstrated that the Morse principle of teeth, not tension, turning chain-driven shafts, means maximum, uniform power transmission at low cost. Talk over your power transmission needs with your Morse engineer. MORSE CHAIN COMPANY, Ithaca, N. Y., Detroit, Mich., Division Borg-Warner Corporation.

UNAFFECTED BY ATMOSPHERIC CONDITIONS

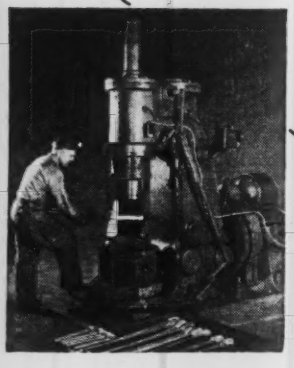
SPROCKETS CHAINS FLEXIBLE COUPLINGS CLUTCHES

MORSE Roller and Silent CHAINS

MORSE CHAIN COMPANY • ITHACA, N.Y. • DETROIT 8, MICH. • A BORG-WARNER INDUSTRY

FAST AND ACCURATE FORGING . . .

The sustained speed of the LOBDELL-NAZEL hammer, striking the same number of blows, whether hard, medium or light, keeps output at maximum. The controlled blows of the hammer, whereby its operator secures the full advantage of each blow struck, produce close limit work with less machining required.



Electrically driven for convenience and economy, the versatile LOBDELL-NAZEL is employed in more than 1100 forge shops in over 70 industries. One or more of these efficient hammers will fit in with your plans for replacement or new installation.

We advise you to get your order in early and avoid delay in delivery. With Government restrictions on production of our equipment lifted, orders are being routed through the plant as received.

WRITE TO US TODAY . . . ask for this free "Hammer Book" on your letterhead, please. We make a size and type forging hammer for almost every need.

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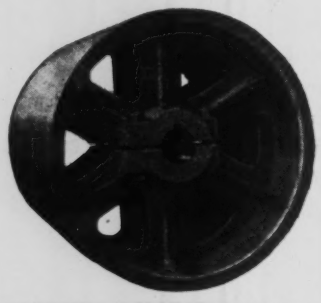
High test cast iron pulleys in all sizes and types

Completely split pulley



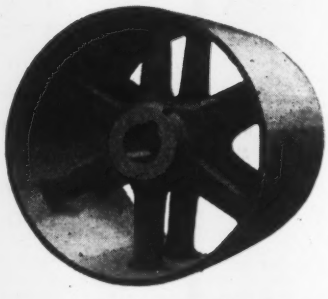
Extra heavy conveyor pulley

JONES cast iron pulleys are true running — they permit higher speeds — no bushings and they can't fall apart — they don't rattle and they look better on most machines.

These pulleys are machine molded, poured of high test cast iron, and are accurately finished and balanced. Multiple piece pulleys, rubber covered pulleys and flywheels can be furnished.

W. A. JONES FOUNDRY & MACHINE CO.
4427 Roosevelt Road, Chicago, Illinois

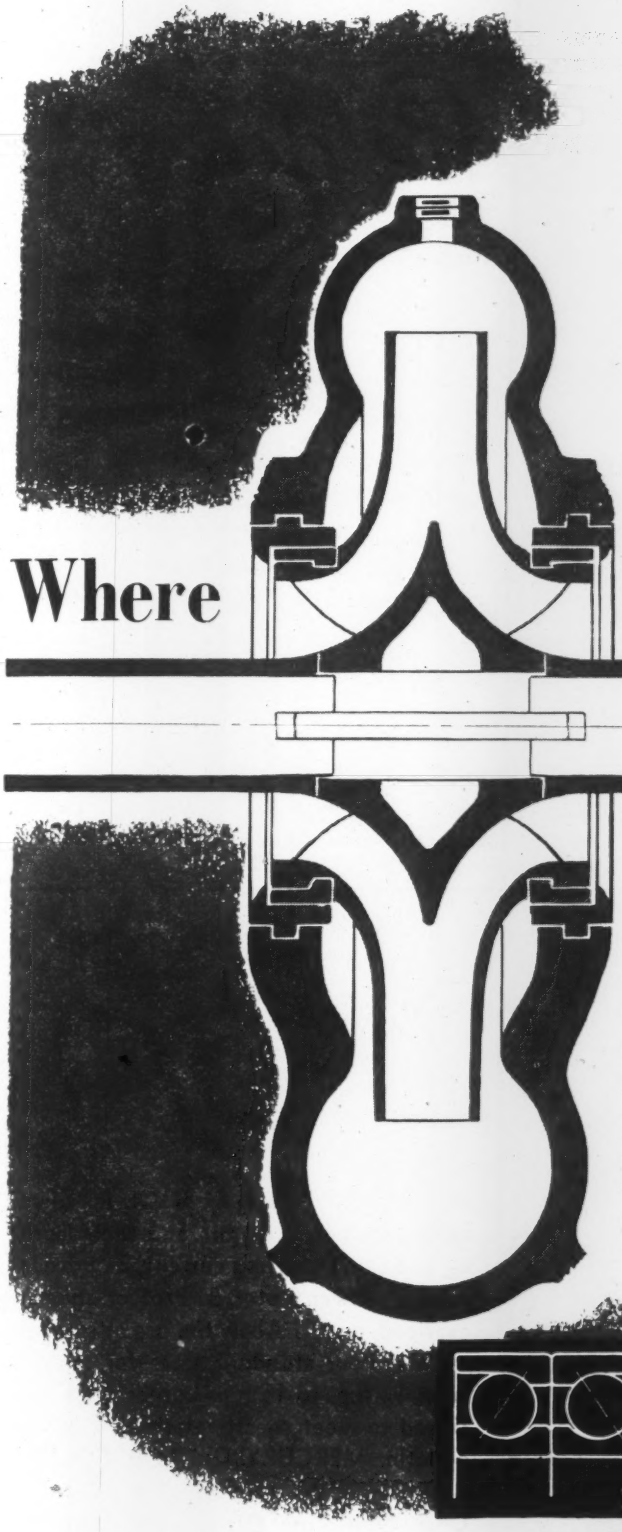
Single arm solid pulley



Double arm pulley

Jones

HERRINGBONE — WORM — SPUR — GEAR SPEED REDUCERS • PULLEYS
CUT AND MOLDED TOOTH GEARS • V-BELT SHEAVES • ANTI-FRICTION
PILLOW BLOCKS • FRICTION CLUTCHES • TRANSMISSION APPLIANCES



A TIGHT-SPOT with a drive shaft . . . that's a centrifugal pump. It's necessary to fit the rotating element that does the pumping so closely inside the housing that clearances are extremely minute. That's how you get suction and it's also how you can get into trouble if there's end-play in the drive shaft. Only ball bearings can take that combination of heavy radial and thrust load and high speed and hold vital clearances.

Where End-Play is FOUL PLAY

It's Fafnir's job to take on tough jobs like this . . . and come up with a series of bearings such as the Duplex Units. Their greater ball complement and double angularity of load lines enable these bearings to take heavy loads with the ultimate in axial and radial rigidity. They maintain precise clearances between rotary element and casing, require minimum attention and last long beyond anticipated life expectancy.

It's the way Fafnir enters into working partnership with machine designers and machine users in offering practical solutions to any bearing problem that makes so many executives say, "Let's put it up to Fafnir." The Fafnir Bearing Company, New Britain, Connecticut.

FAFNIR BALL BEARINGS

MOST COMPLETE LINE IN AMERICA

"Handsome is as Handsome does"

HALLOWELL DE LUXE SHOP FURNITURE

Fig. 1731

"Hallowell" Bench, with backboard, two four-drawer tiers and lower shelf.

That's what they say—and "Hallowell" DeLuxe Shop Furniture follows the old maxim by not only *looking good,* but also by providing the most serviceable, comprehensive and interchangeable equipment. Of the same rugged construction as other "Hallowell" Shop Furniture, these pieces wear so well, they seem *ever-lasting.* You'll want to include "Hallowell" DeLuxe Shop Furniture in your plans for shop expansion or office modernization. And you'll find just what you want, too, for there are interchangeable shelf, drawer and cabinet units . . . allowing a wide choice of styles. Write today for the "Hallowell" Catalog.

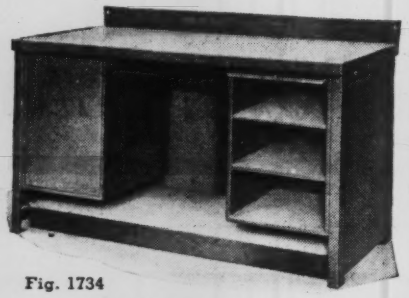


Fig. 1734

"Hallowell" Bench, with backboard, lower shelf and two receding door cabinets, one unit open.

STANDARD PRESSED STEEL CO.

JENKINTOWN, PENNA. BOX 558

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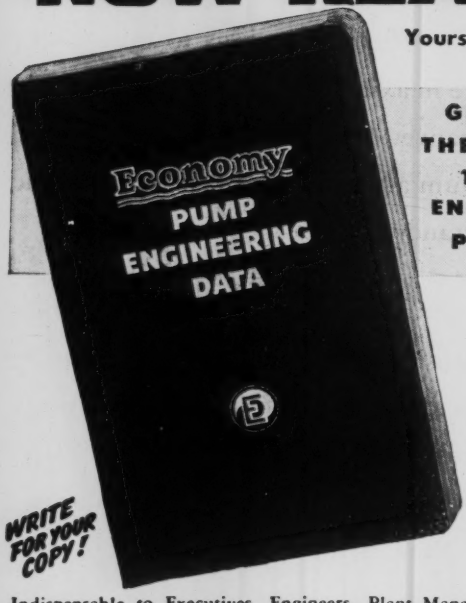

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A timely contribution to industry—416 pages of factual data just when vital post-war pump problems require authentic facts, sound experience and advanced engineering practice.

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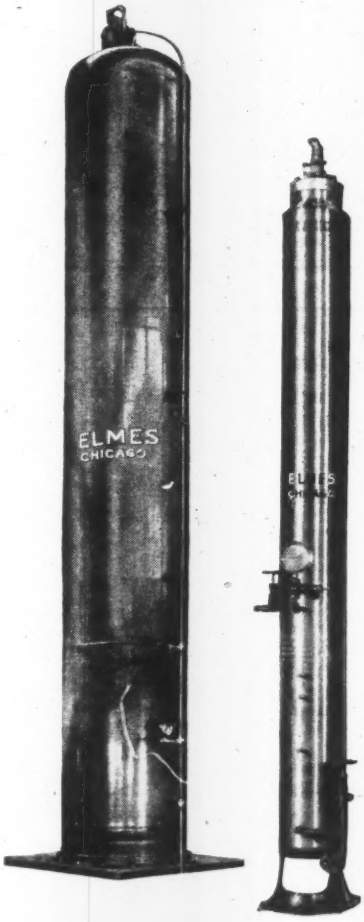
HAMILTON, OHIO • U. S. A.

MERCURY CLUTCHES, installed between electric motors and their loads — 1) Reduce starting current, 2) Provide a better power factor, 3) Protect against overload, and 4) Allow the use of smaller motors. Four standard sizes for motors from ¼ h.p. to 15 h.p. Larger sizes designed to meet specifications. Write for bulletin. MERCURY CLUTCH CORPORATION, 1504-12th St., S.W., Canton, Ohio. New York Office: 19 Rector St.

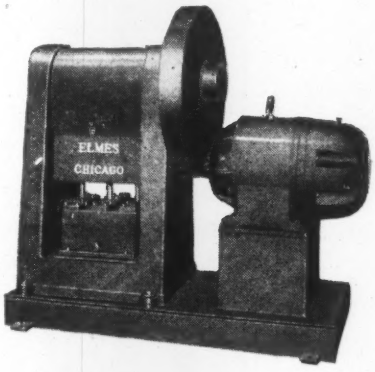
Better Pressure Regulation—No Line Shocks—Smooth Flow

GET THE MOST OUT OF HYDRAULIC POWER



BALLASTED BY COMPRESSED AIR

Elmes accumulators have no internal moving parts. Pistonless design eliminates packings. Simplified controls maintain desired pressures; prevent loss of accumulator supply through line failure. Made in all sizes and capacities. Can be set on the usual factory floor.



A SINGLE PUMP-ACCUMULATOR SYSTEM SERVES ANY NUMBER OF PRESSES

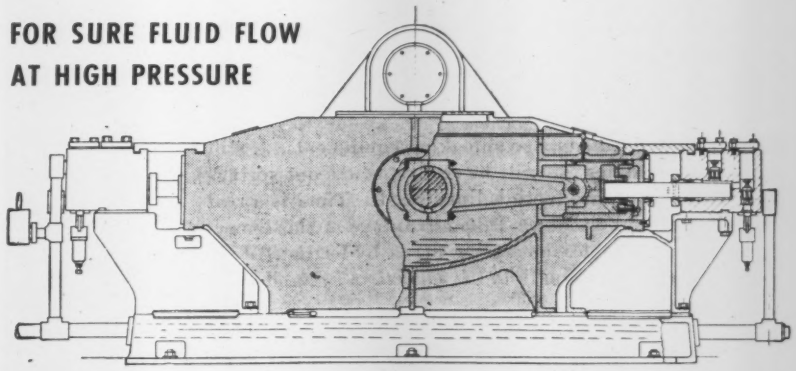
No matter how *many* presses you operate—how *large* they are, or *what* they do—a *single* Elmes pump-accumulator system can supply abundant power for *top production,* all day long.

No job is too *tough,* or too big. Elmes patented controls coordinate all functions, satisfy wide demand *fluctuations,* and maintain an ample *pressure reserve.* Smooth-flowing, *shockless* power is precisely regulated for fast, *money saving* press performance.

Whether you contemplate a whole new pressroom installation, or a revamping job for lower costs, the Elmes pump-accumulator system merits your immediate investigation. Write us, *today.* We'll be glad to tell you all about it.

ELMES HYDRAULIC EQUIPMENT

FOR SURE FLUID FLOW AT HIGH PRESSURE



(Above) The famous Elmes horizontal six-plunger pump with overlapping impulses for really smooth performance. A rigid, one-piece housing (shaded area on drawing) absorbs shocks, preserves alignment. Designed throughout for efficiency, long life, easy servicing. Many patented features. 150 to 500 h.p. Pressures to 35,000 p.s.i. —and *higher.* (Left) Elmes vertical, three-plunger pump for requirements in the 3 to 100 h.p. range. Quality-built. Durable. Thoroughly dependable, Elmes builds the right hydraulic pump for every high-pressure purpose.

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For SEVERE RADIAL and SHOCK LOADS

PRECISION ROLLER BEARINGS afford the following outstanding advantages . . . . Solid, cylindrical rollers, held to infinitesimal limits of accuracy, provide larger steady load and shock capacity than any other single-row bearing, together with a temporary overload capacity of 50% . . . Short roller construction affords ideal load distribution and greater wear resistance . . . Extruded bronze, machined and balanced, heavy-duty retainer is land-riding, relieving the rolling elements of its weight . . . Extreme refinement of design and finish gives a lower coefficient of friction under severe load than any other type of bearing and permits speeds up to 35,000 R.P.M. . . . PRECISION ROLLER BEARINGS interchange in size with all standard ball bearings . . . Write for the catalog. Let our engineers work with you.

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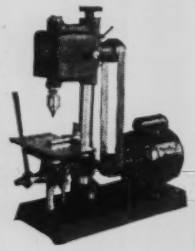
PRECISION BALL, ROLLER and THRUST BEARINGS

More and Better Work With Less Effort

HAMILTON SENSITIVE TAPPER



NO BREAKAGE of even the smallest and finest taps ... can be used on any threadable material . . . for smallest threads up to and including 10-32. For tapping on instrument, camera, watch, business machine operations where sensitivity and precision count.

Write for Bulletin Dept. 18

THE HAMILTON TOOL CO. HAMILTON, OHIO

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November, 1945 CARD INDEX Vol. 67, No. 11

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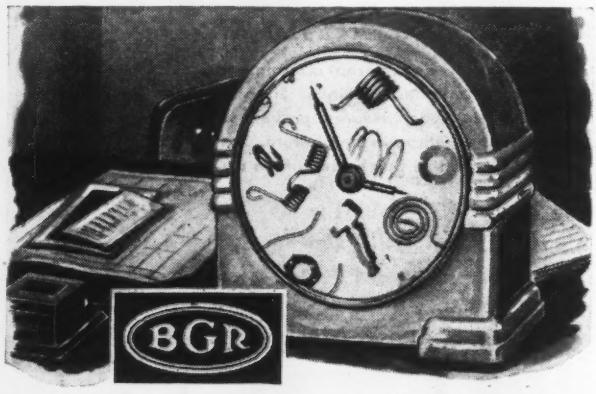
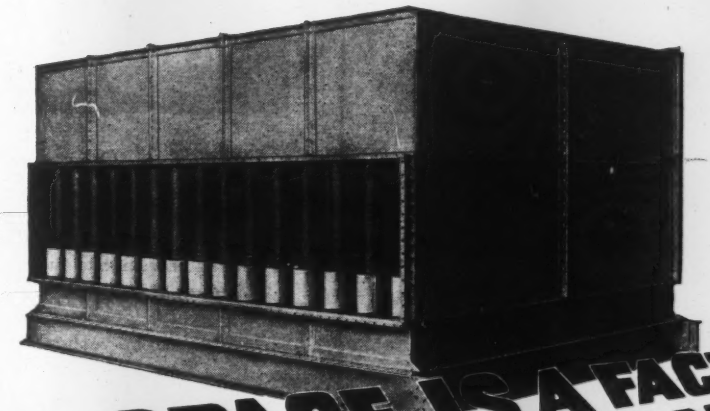
Time savers - for "New Products in a hurry!"

YOU CAN SAVE TIME TODAY by placing the design and production of springs for your mechanisms in the capable hands of B-G-R engineers. They will recommend the proper material and type of action best suited to the performance desired . . . based on experience covering thousands of widely varying conditions of use.

At both B-G-R plants, springmaking equipment . . . still hot from war schedules . . . will be ready to turn out springs in any amount your production lines need. Time is a real factor in product shift today. Take advantage of this opportunity to unload troublesome spring needs by letting B-G-R shoulder the problem. You'll find *it saves time* . . . and often needless expense.



SPRINGS *SMALL STAMPINGS* *WIRE FORMS*



WHEN SPACE IS A FACTOR IN DUST COLLECTION

To the many plants faced with meeting severe conditions of local dust ordinances and yet lacking suitable space for a conventional dust collector installation, the following examples of Thermix Tubular installations will provide food for thought:

● In a 125,000 lbs. per hour unit, a Thermix Tubular was installed at the bottom of the tubular air preheater . . . *in the same floor area* . . . using the preheater hoppers for the dust collector.

● A Thermix Tubular Dust Collector was installed *in the bell* of an 8′ diameter stack, handling a 300,000 lb. per hour pulverized fuel boiler.

● In a large paper mill using five pulverized fuel boilers, designs of which did not include provisions for a dust collector, Thermix Tubular Collectors were successfully installed.

These and many others are testimony to the minimum space requirements of Thermix Tubular Dust Collectors, available in extremely compact, easily installed six and nine inch diameter tubes . . . their high efficiency is an established fact.

Write for our suggestions for solving your dust collection problems.

●

THERMIX ENGINEERING COMPANY

Project and Sales Engineers

First National Bank Bldg. Greenwich, Conn.

PRAT-DANIEL CORPORATION

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...read what "just a few" recipients say about it:

ENGINEER OF AIRCRAFT MANUFACTURER SAYS:
"I am pleased to say that it is the best commercial job I have seen covering this subject, its simplicity and completeness leaving little to be desired."

EXECUTIVE OF A METALS SUPPLY CO. SAYS:
"We find it the most understandable and practical publication of its type which has ever come to our attention."

Note:
The above are only several of many such letters received by us.

A 40-page, flat-opening, flexible-bound *Reference Book* that should be in the hands of every Engineer who specifies or uses *Bronzes*. Due to the cost of preparing and producing this *useful* book, we can only send it to those who request it in writing on their business letterhead—or, of course, those who fill-in and mail us the coupon attached hereto—and remember, there's over 35 years' experience in casting Bronzes behind us.

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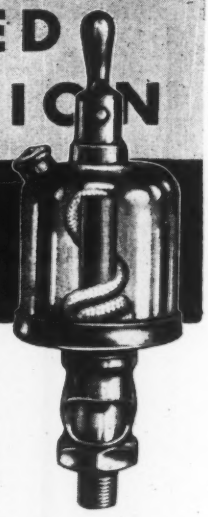
FILTERED LUBRICATION

GITS Wick Feed Oilers



Wick Feed Oiling is the cleanest method of lubrication you can get—no foreign matter or dirt can be transmitted through the wick to the bearing. It can be varied to supply just the right amount of not-too-heavy oil at any one of several locations on each bearing whether it be vertical or angular position; high, low or intermitted in speed. Gits Wick Feed Oilers are available in a wide range of styles, sizes and materials. Ask for complete information on this type of oiler.

Gits Catalog No. 60 gives you 172 pages of Oiler, Oil Seal and Lubricating Device information. . . . Write for it.

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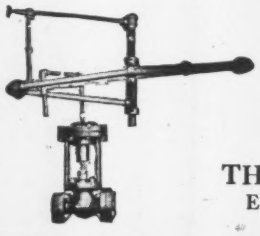
Maintain a constant water level in your boilers, feeding them in proportion to evaporation.



Squires
BOILER FEED WATER CONTROLLERS

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Cleveland, Ohio

FOR PRECISION INSTRUMENTS

MINIATURE PRECISION BALL BEARINGS
(WORLD'S SMALLEST BALL BEARING)

Radial and Pivot types for taking extra heavy radial and thrust loads in precision instruments and other highly sensitive devices, to minimize friction, space, weight and overcome starting torque.

Radial Series (5 Sizes) 1/8" to 5/16" O. D.
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Actual Sizes *Actual Sizes*

MINIATURE *Precision* BEARINGS
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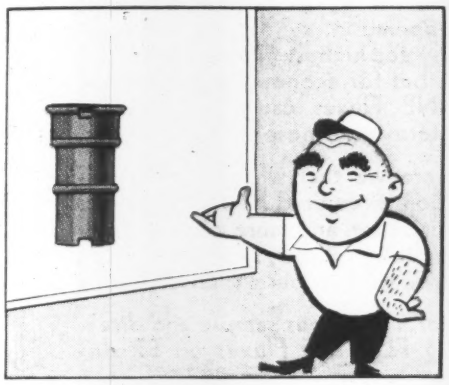
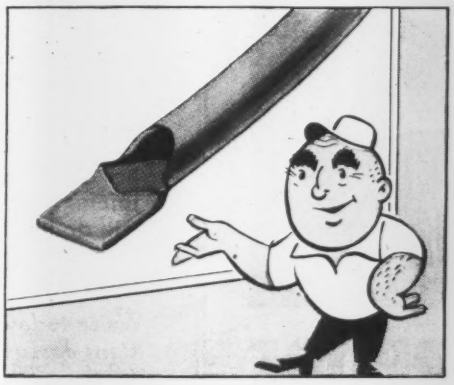
SEE HOW · EASILY
BUNDYWELD IS FABRICATED

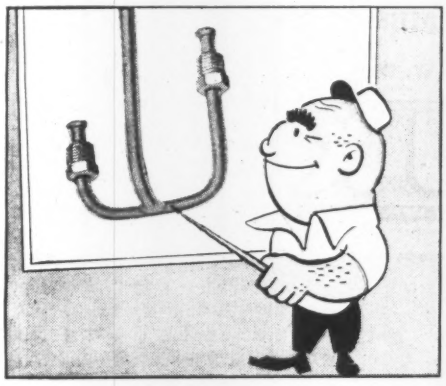


1 THIS SMALL PIECE of Bundyweld is double upset, flanged, expanded and notched.



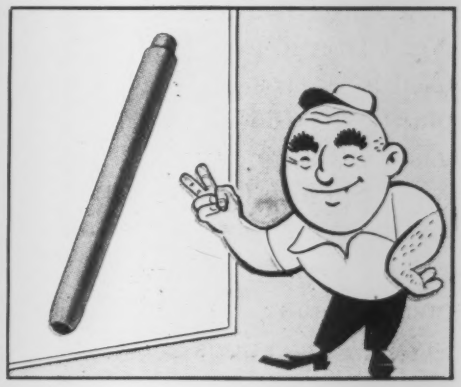
2 A NOTCHED and flattened end is simple with Bundyweld Steel Tubing.

3 SHARP BENDS are easily made without flattening. Note the use of compression fittings.



4 THIS PART shows how Bundyweld may be saddle flanged, pierced and silver soldered together for a right angle connection.

5 SMALL TUBES take the double flare as readily as the larger sizes. This part fabricated from 3/16" O.D. Bundyweld.



6 TWO SCREW MACHINE operations . . . a sharply cut shoulder at one end and shaping for ball seat at the other end.

AN UNUSUAL MANUFACTURING PROCESS

1 Bundyweld Tubing is made by a process entirely different from that used in making other tubing. A single strip of copper-coated S.A.E. 1010 steel is continuously rolled twice laterally . . .

2 . . . into tubular form. Walls of uniform thickness and concentricity are assured by the use of close tolerance cold rolled strip. This double rolled strip passes through a furnace where the . . .

3 . . . copper coating fuses and alloys with the double steel walls. After brazing and cooling, it becomes a solid double wall steel tube, copper brazed throughout 360° of wall contact . . .

4 . . . copper coated inside and out, free from scale, closely held to dimensions. Hard or annealed in standard sizes up to 5/8" O.D. Special sizes cold drawn. Also in Monel and nickel.

BUNDY TUBING

ENGINEERED TO YOUR EXPECTATIONS

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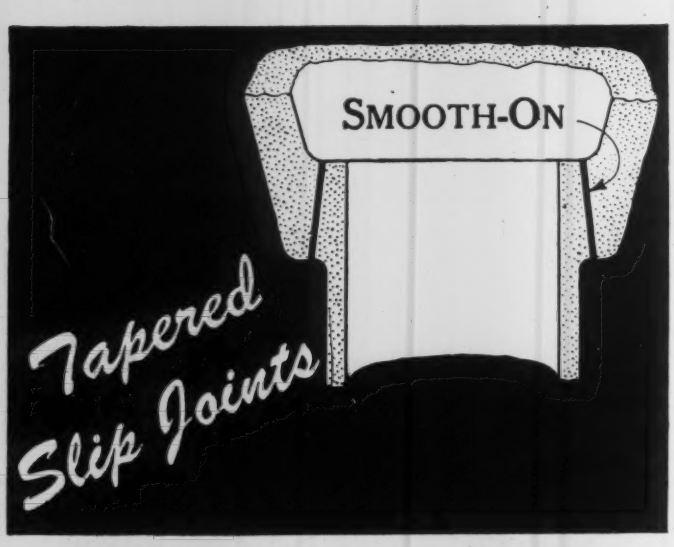
Pacific Metals Co., Ltd. 3100 19th St. San Francisco 10, Calif.	Standard Tube Sales Corp. 1 Admiral Ave. Maspeth, N.Y.C., N.Y.	Lapham-Hickey Co. 3333 W. 47th Place Chicago 32, Illinois	Rutan & Co. 112 S. 16th St. Phila. 2, Pa.	Eagle Metals Co. 3628 E. Marginal Way Seattle 4, Wash.	Alloy Metal Sales Ltd. 861 Bay St. Toronto 5, Canada



..MADE LEAK-PROOF

For lasting insurance against leaks at slip joints in cast iron economizer tubes and other locations, always set the joint with Smooth-On No. 1 Iron Repair Cement. That is the method used for years in a Washington, D. C. filtration plant. At 165 lbs. working pressure, with flue gases entering at 450° F., not one joint, sealed with Smooth-On No. 1 has ever developed leaks.

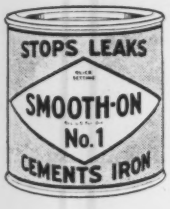
This typical Smooth-On "stitch in time" is one of many practical, time-saving, money-saving suggestions shown in the

FREE

Smooth-On Repair Handbook

which you may secure by simply mailing the coupon. Cracks sealed. Leaks stopped. Loose parts and fixtures made fast. Pocket size. 40 pages. 170 diagrams. Clear, tested, short-cut directions. Handy index. Over 1,000,000 copies already put in circulation. A book every mechanic, engineer and repair man should have handy.

In 1-, 5-, 25-, and 100-lb. sizes at supply houses. If yours hasn't Smooth-On, contract us direct.



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Please send me Quick Patch folder and Smooth-On Repair Handbook.

Name.....

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12-45 .....

Do it with SMOOTH-ON
The Iron Repair Cement of 1000 Uses

"FLUXINE" Fluxes are the result of fifty years of scientific research into the metal-joining field. There are 89 FLUXINE Fluxes . . . one for every welding, silver soldering, brazing, and soft soldering operation . . . each with its own properties, designed for a particular metal-joining operation. All have been perfected not only for highest efficiency, speed, and long life, but for economy and safety as well. FLUXINE Fluxes cause no injurious fumes to irritate eyes or nose of the operator.

So confident are we that wherever a metal-joining operation is required FLUXINE Fluxes will do it better, faster, and more economically than any competitive fluxes, that we will be glad to have you try it at our expense.

Write today for a generous sample and directions for using FLUXINE Fluxes on 57 different metals.

Ask your jobber . . . he knows the FLUXINE line produces the best results with the greatest economy.

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FLUXINE
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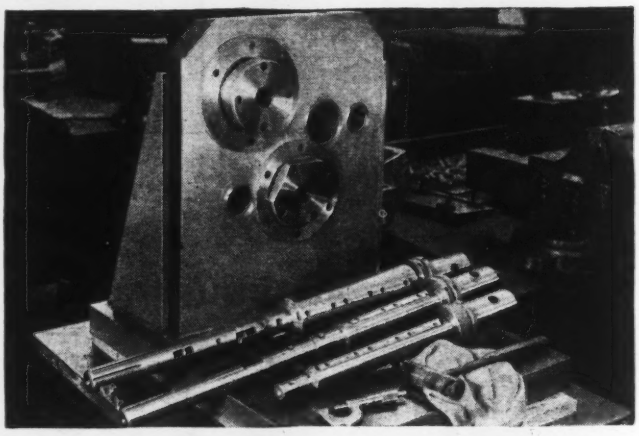
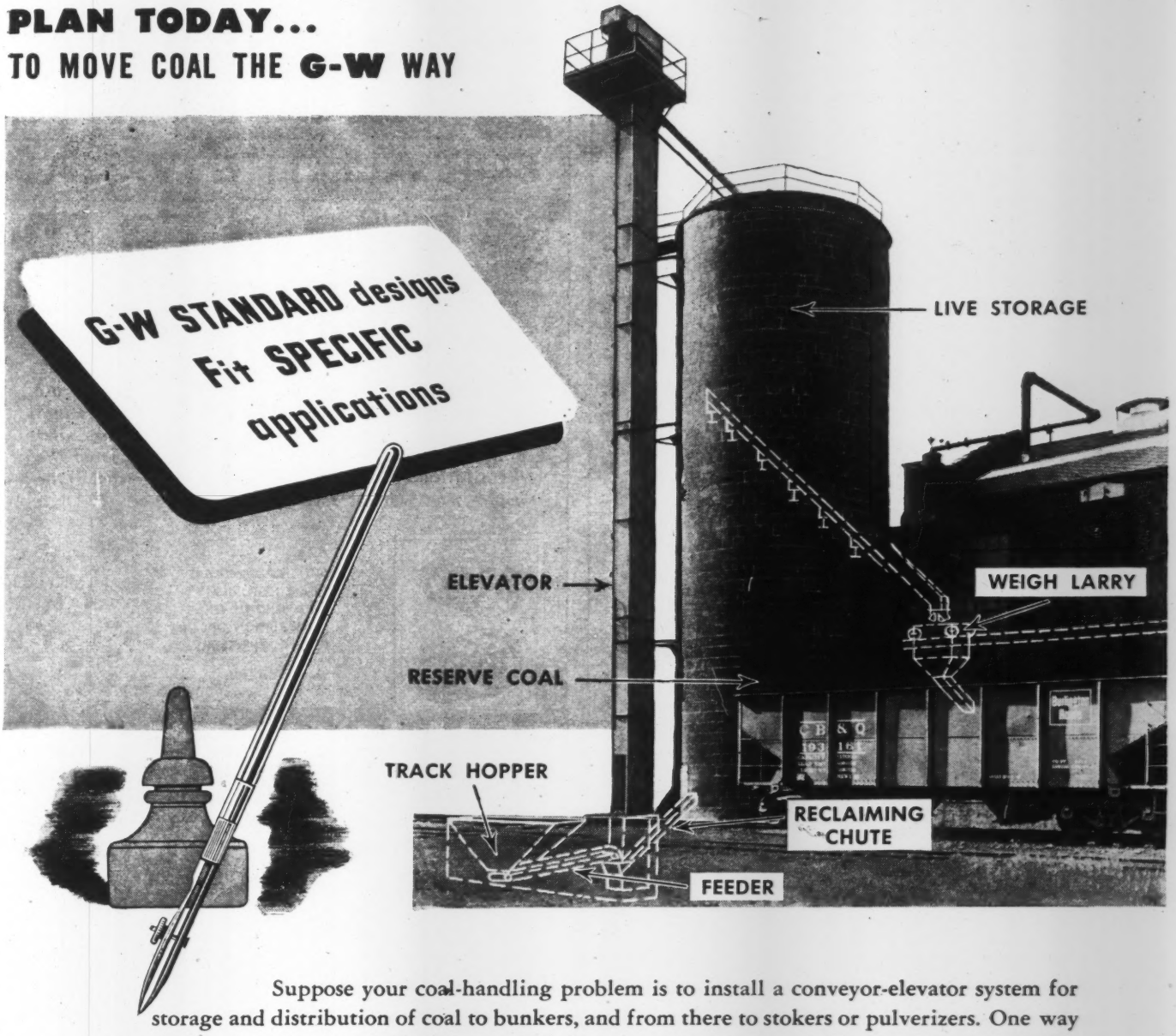


EXAMPLE OF MERZ
Precision Tooling

● The precision boring fixture shown here is but one example of the versatility of MERZ engineering design and manufacture. Others will be shown to you, on request. Facilities and equipment second to none in the Central States, insure delivery of exactly what you need, at minimum cost and at the earliest possible date. Write for literature describing our highly specialized service, and MERZ standard A.G.D. gages, available from stock.

MERZ *Engineering Company*
INDIANAPOLIS 7, INDIANA

PLAN TODAY...
TO MOVE COAL THE G-W WAY



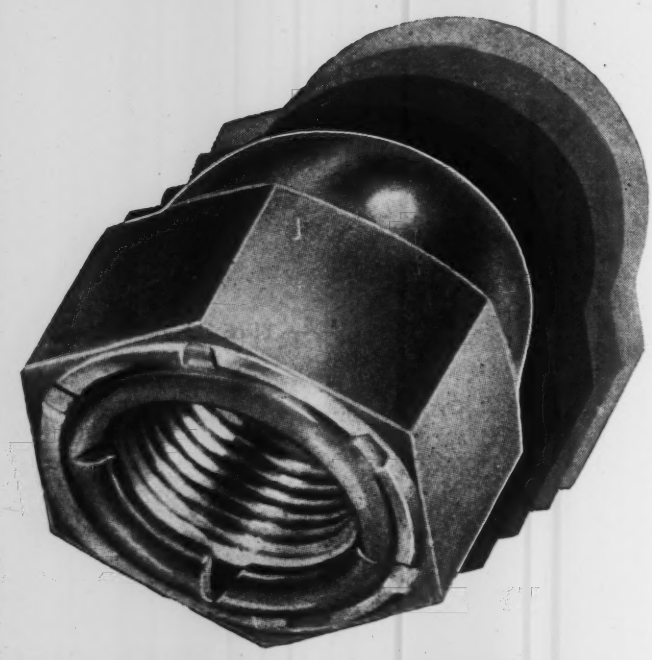
Suppose your coal-handling problem is to install a conveyor-elevator system for storage and distribution of coal to bunkers, and from there to stokers or pulverizers. One way it could be solved is graphically illustrated by this composite photo and diagram. The installation shown comprises *standard* G-W equipment co-ordinated into a handling system meeting *specific* requirements—the moving of coal, mechanically, from car to live storage and reserve storage . . . thence to the boiler room. Or your problem may be to install the best type of conveyor to distribute coal evenly and with no segregation throughout the bunkers . . . or, where a number of boilers are served by a common bunker, to decide whether movable spouts or traveling weigh larries will deliver the coal with greatest efficiency and economy.

To these problems, and many others, G-W experts bring specialized experience as designers and builders of coal storage and coal and ash handling systems for over 130 years. In this time Gifford-Wood has not only developed efficient standard equipment but has acquired experience which particularly qualifies them to design, build and install special systems to meet unusual conditions. Gifford-Wood Co.,
420 Lexington Ave., New York 17, N. Y.;
565 W. Washington St., Chicago 6, Ill.
Factory—Hudson, N. Y.

DO YOU KNOW?—G-W is also *Handling Headquarters* for Industrial Conveying and Elevating Systems . . . for Ice Handling Tools and Ice Processing Equipment . . . for Infra-Red Baking and Drying Systems . . .

G-W HANDLES IT
Faster · Easier · Cheaper

GIFFORD-WOOD
SINCE 1814



full locking safety *—under heat or corrosion!*

THERE'S NO deterioration, no weakening of the structure and locking security of the **An-cor-lox** lock nut under high heat.

And the gases and liquids encountered in process industry operation will not affect its efficiency. The complete seal produced by the flattened locking ring prevents passage of liquids and gases even under pressure.

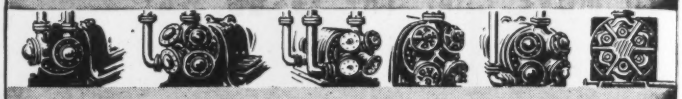
A further advantage of **An-cor-lox** all metal construction lies in its adaptability to the use of special alloys for meeting extreme conditions of service. *Engineering data is available in our latest bulletin, which will be mailed you on request.*

2228

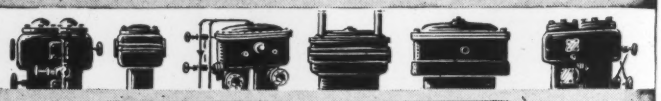
An-cor-lox *Lock Nuts*

An-cor-lox Division
LAMINATED SHIM COMPANY, INCORPORATED
93 Union Street · Glenbrook, Conn.

FOR ALL THE H.D.A.

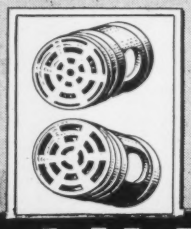


FOR ALL THE V.S.A.

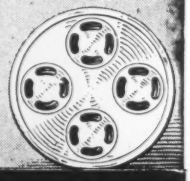


J. H. H.
VOSS VALVES
REG. U.S. PAT. OFF.

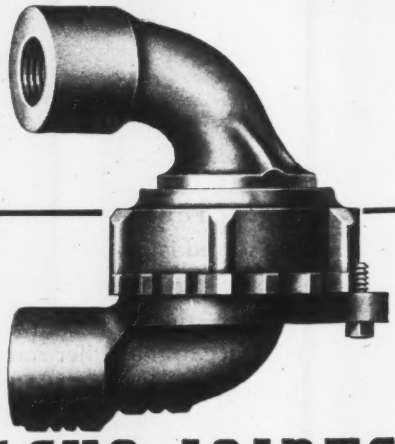
Thousands of Ammonia, Air, and Gas compressors are running for years with VOSS VALVES *— the valves that are synonomous with long life, minimum repairs, and uninterrupted service. Economies resulting from the installation of* VOSS VALVES *will repay the cost of the improvement within a short time.*



WRITE FOR CIRCULARS CASE HISTORIES, AND SEND US THE DESCRIPTION OF YOUR COMPRESSORS



J.H.H. VOSS CO.
785 EAST 144TH ST., NEW YORK, U.S.A.



FLEXO JOINTS

make pipe flexible with the safety of rigid fittings

FLEXO JOINTS are used wherever a flexible or swing pipe joint is required to convey steam, compressed air, water, oil or other fluids through pipe lines that are moved or swung in different directions. They are also used to supply machinery or equipment with any fluid while in motion.

FLEXO JOINTS are reasonable in first cost, have long life and their maintenance cost is negligible. They are really trouble proof; just 4 simple parts—no springs, delicate parts or ground surfaces.

Pipe sizes from 1/4 inch to 3 inches; all pressures up to 1350 lbs superheated steam.

Write for bulletin.

FLEXO

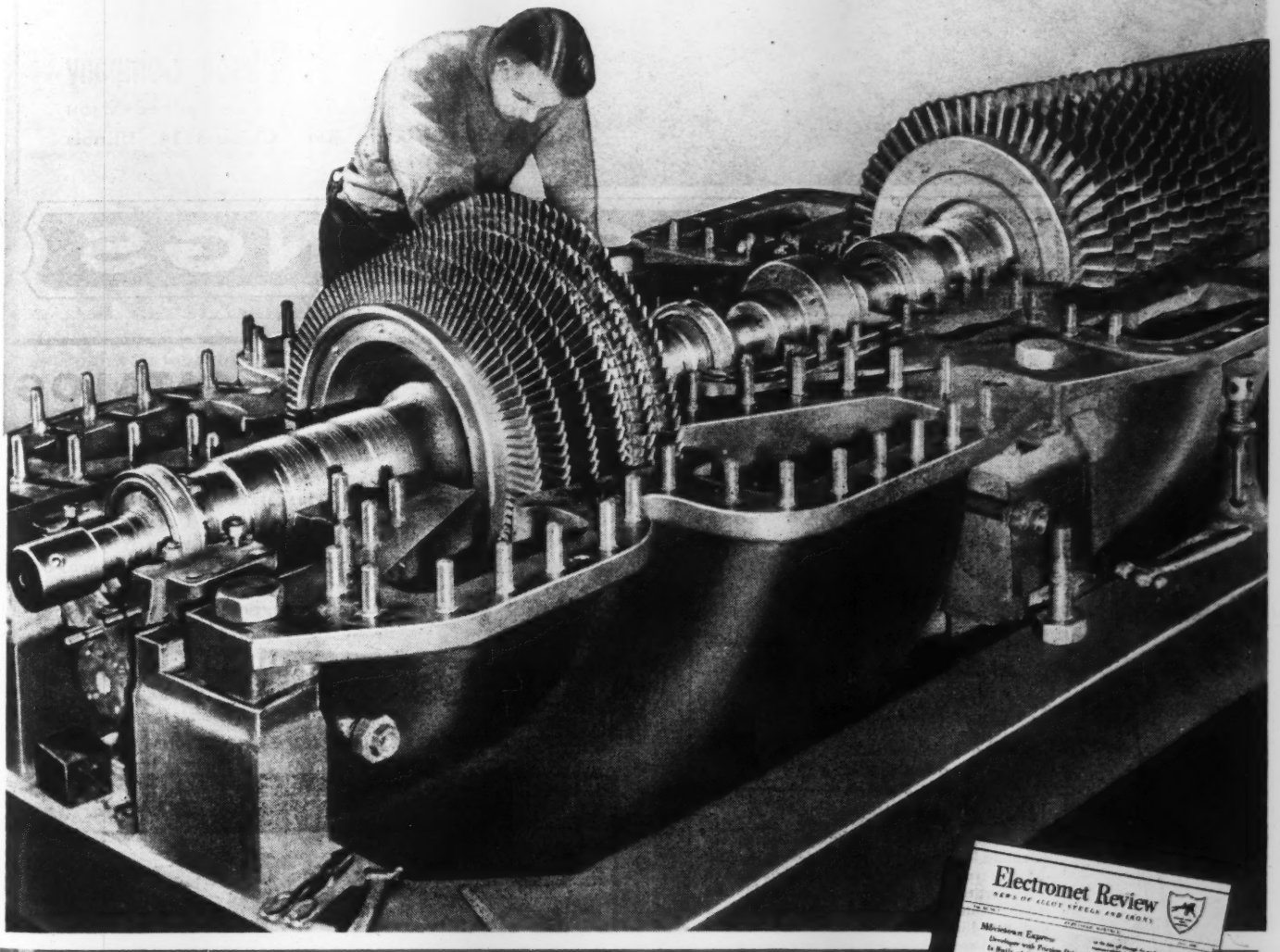
FLEXO SUPPLY COMPANY Inc.,
4219 Oliver Str. St. Louis (8) Mo.

In Canada:
S. A. Armstrong, Ltd.
115 Dupont Str. Toronto (5) Ont.

STAINLESS STEEL "*fire-eater*"

Engineers have long dreamed of building gas turbines, but, only recently have they had heat-resisting stainless steels that could stand up under the terrific heat and corrosive action of the flaming gases. The successful operation of stainless steel gas turbines, like the one pictured below, shows that these machines are now a practical power source for many industries.

While stainless steel is essential in gas turbines, there are many less severe applications in industry where this tough, heat-enduring metal also means longer life, fewer shut-downs, and more economical operation.



Other uses of stainless steel are described in ELECTROMET REVIEW, published by ELECTRO METALLURGICAL COMPANY, a Unit of UNION CARBIDE AND CARBON CORPORATION. ELECTROMET does not make steel, but produces the ferro-alloys used in its manufacture. If you need this complimentary publication, write to ELECTRO METALLURGICAL COMPANY, 30 East 42nd Street, New York 17, N. Y.

Buy and Hold United States Victory Bonds and Stamps

SOMETHING SPECIAL in SMALL ORDER SERVICE

You may need only experimental development of a spring—or emergency replacements—or a small production lot. But you need *fast service.* Gibson's Small Order Department, made more flexible and fast-acting, now gives you better-than-ever service—with the same high standards of quality prevailing. It's a service of convenience—use it with confidence.

The William D. Gibson Company

DIVISION OF ASSOCIATED SPRING CORPORATION

1800 Clybourn Ave., Chicago 14, Illinois

GIBSON-SPRINGS

WAPPLER

BORESCOPE

You can turn a hole Inside Out or See Around a Corner

with the

Wappler Industrial Telescope

Inspection Problems in the Examination of Internal Surfaces May Be Solved by Means of the

WAPPLER BORESCOPE

A telescopic instrument containing a lighting circuit and a lens system. Various angles of vision for different types of visual systems are available. You may select the type best suited for your particular requirements, with the assurance that the resultant undistorted image will be clear and concise.

If you have an inspection problem, the Wappler Borescope will help solve it for you. An accurate description, blueprint, or better still, the part itself forwarded to our Industrial Division will have our immediate attention with recommendations for a suitable instrument to solve your problem.

Write for Booklet . . . it's Free

INDUSTRIAL DIVISION

AMERICAN CYSTOSCOPE MAKERS, INC.

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FLOAT CATALOG

Complete data on standard and special floats of copper (plated and unplated), stainless steel, steel, aluminum, monel, nickel, or brass, together with buoyancy tables and other useful information for designers is yours for the asking. Write for our general catalog, and take advantage of years of specialized experience.

CHICAGO FLOAT WORKS, INC.

"Nothing but Floats" since 1915

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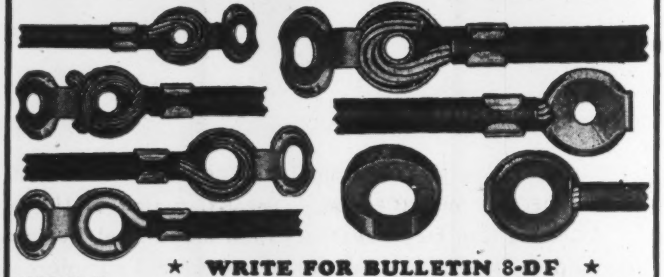
FOLDING **DOUBLE** CUPPED WASHER LUGS

A SIZE and TYPE *for every need!*



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K&H **KRUEGER & HUDEPOHL**

WALSH BUILDING CINCINNATI 2, OHIO

Representatives—Sales Agencies
Business For Sale
Partnership—Capital
Manufacturing Facilities

OPPORTUNITIES

Positions Open—Positions Wanted—Equipment, Material, Patents, Books, Instruments, etc. Wanted and For Sale

Answers to box number advertisements should be addressed to given box number care of "Mechanical Engineering", 37 West 39th St., New York 18, N. Y.

RATES Classified advertisements under this heading in MECHANICAL ENGINEERING are inserted at the rate of $1.00 a line. 80 cents a line to members of A.S.M.E. Seven words to the line average. A box number address counts as one line. Minimum insertion charge, 5 line basis. Display Advertisements carried in single column units of multiples of one inch at flat rate of $15 per inch per insertion. Maximum Size: 1 column, 7 inches deep; 2 columns, 3½ inches deep. Copy must be on hand not later than the 10th of the month preceding date of publication.

Four Pages (135-136-137-138) of Opportunities this month

POSITIONS OPEN

POWER ENGINEERS

Engineers for field service starting up new boilers and auxiliary equipment for large manufacturer. Must be technical graduate or have good background of operating experience with pulverized fuel. Salary to start $200 to $400 per month depending upon qualifications.

Address CA-1555,
care of "Mechanical Engineering" or telephone Plaza 9-6218, N. Y.

DRAFTSMEN

Large steel company in Pittsburgh area has several opportunities for draftsmen with high school or college education and experience in the following areas: design of steel mill and steel foundry products; railroad track accessories; layout and design of steel mills, blast furnaces, open hearth furnaces, and power plants; design of fabricated concrete bars; layout of electric power and control equipment; general mechanical design and layout. Please submit details, statement of experience and education, inexpensive photograph, and required minimum earnings.

Address CA-1495,
care of "Mechanical Engineering."

WANTED

DESIGNERS
ARCHITECTURAL
STRUCTURAL
POWER PIPING
ELECTRICAL

5 to 10 yrs. experience in Power Plant or Heavy Industrial Work

Positions in Philadelphia

UNITED ENGINEERS & CONSTRUCTORS INC.
1401 Arch Street Philadelphia 5, Pa.

MACHINE DESIGNERS

Experienced on the design of special machinery. Excellent opportunity for first class men interested in steady positions. Also steady positions for tool designers.

Only men with a record of successful achievements will be considered. In replying furnish information preliminary to a conveniently arranged interview. Address Employment Manager, Taft-Peirce Mfg. Co., Woonsocket, R. I.

MACHINE DESIGNERS AND DRAFTSMEN

For development, design and detailing of special and experimental machinery. Men with creative ability required. Experienced in such lines as automatic, semi-automatic, or ordnance equipment.

Good post-war prospects.

E. I. du Pont de Nemours & Co., Inc.
Personnel Division
Wilmington 98, Delaware

Post-War Expansion
Requires the Services of

DESIGNERS AND DRAFTSMEN

Specialized in the following Fields:

Machine Design
Plant Layout
Equipment and Process Design
Air Conditioning
Electrical Design
Product Design

College graduates or equivalent in experience will be considered.

Work locations in Binghamton or New York City.

Write, giving details of experience and salary requirements.

ANSCO
29 Charles Street
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MECHANICAL ENGINEER

MUST HAVE . . .

- Sales Experience
- Factory Management Experience
- Ability to Speak Spanish

LOCATION MEXICO CITY

Major Oil Company

Must be available for personal interview in New York City

Give age, education and experience.

Address CA-1619,
care of "Mechanical Engineering"

ENGINEERS WANTED

MECHANICAL
ELECTRICAL
CIVIL

Preferably those with

EXPERIENCE ADAPTABLE TO AIRCRAFT

LAYOUT DRAFTSMEN
AERODYNAMICISTS
STRESS ANALYSTS

Or others with at least several years of engineering experience which will serve as a basis for aircraft work.

Permanent positions are available in the engineering of such planes as the Martin 202 transport, commercial version of the Martin MARS, and other new commercial and military commitments. Write including full information on education, experience and background,

to DIRECTOR OF ENGINEERING PERSONNEL
The Glenn L. Martin Company
BALTIMORE 3, MARYLAND

PLANT ENGINEER

Old established chemical industry requires engineer to take charge of maintenance of going plant, and design and construction of new plant expanding operations.

Must be good engineer and good administrator. Ohio location.

Address CA-1647,
care of "Mechanical Engineering."

A well-established,

progressive manufacturing company near New York City requires for its metallurgical department:

One ferrous Metallurgist

One Mechanical Engineer

One Physicist with an electrical background or an Electrical Engineer

College education necessary. Two to five years' experience desired. Positions permanent with good opportunities for advancement. Write fully giving details of your experience, education, and salary desired.

Address CA-1641
care of "Mechanical Engineering."

OPPORTUNITIES FOR DRAFTSMEN

Structural Detailers
Heavy-Machine Designers

Experienced in detailing and checking drawings

ALSO

STRESS-STRAIN CALCULATOR

High-pressure equipment, Intensifiers, pumps, Pressure vessels, high-pressure valves.

Major in all higher mathematics
State experience and salary desired.

ADDRESS EMPLOYMENT OFFICE
BETHLEHEM STEEL COMPANY
BETHLEHEM, PA.

ENGINEERING DRAFTSMAN

Exceptional openings for experienced men for large midwest corporation. We are interested in men who can handle electrical, industrial layout or general plant engineering. A background in industry is important. In reply describe fully your experience, also age, and salary expected.

Address CA-1652,
care of "Mechanical Engineering."

CHIEF DRAFTSMAN

We want an engineer with a mechanical engineering degree from a recognized engineering college to take charge of a small engineering and drafting department in a medium sized manufacturing plant located in northern New Jersey. Must be at least 38 years of age. Should have five to ten years' experience on the drafting board. We must have a man of good personality, who can co-operate with and get co-operation from others in engineering department. Salary to be paid will be commensurate with responsibility. Man we select must be capable of using own initiative in laying out mechanical mechanisms from rough sketches. Will be responsible to Plant Engineer. Some experience in a process industry is essential. You will have good working conditions, congenial people to work with, and you will be working for a progressive company manufacturing a wide diversity of products. Your letter will receive full consideration if it contains full information regarding education, experience, salary requirements, etc.

Address CA-1651,
care of "Mechanical Engineering."

ASSISTANT TO PRESIDENT

Excellent opportunity for engineer with executive ability to assist President of a nationally known manufacturer in the East. Applicant must have experience in supervising construction and installation of new equipment, development of new manufacturing processes, and factory management. Food processing experience preferred but not essential. M.E. degrees is minimum educational requirement. Replies, which will be treated in confidence, must state full particulars, including salary requirements.

Address CA-1621
care of "Mechanical Engineering."

We are expanding our production engineering department and have openings for men with experience on modern production methods and plant layout.

This is an excellent opportunity for men with initiative and ability, who are interested in steady employment with a progressive Company.

Reply by letter to Chief Production Engineer, giving age, education, experience, personal data and salary expected.

PERFECTION STOVE CO.
7609 Platt Ave.
Cleveland 4, Ohio

ARTHUR G. McKEE & COMPANY

Designers and Builders of Steel Plants and Oil Refineries in all parts of the world.

ARE INTERESTED IN YOUR SERVICES

if you are a skilled Engineer or Draftsman experienced in the making of Design Drawings of Structural Steel, Reinforced Concrete, Pressure Vessels, Piping, or other Mechanical work.

Location: Cleveland, Ohio.

Present favorable outlook means long term engagement for qualified men.

Request application form or send *complete* details of experience and personal data to

2300 CHESTER AVENUE
CLEVELAND, OHIO

MECHANICAL AND CHEMICAL ENGINEERS

with experience in process industries, are required for the expansion of the Development Engineering Department of a division of a prominent, nation-wide organization.

The positions available are permanent, with excellent post-war prospects.

Submit a full description of experience, education, personal status, present and expected salary. Enclose snapshot if available.

Our own employees have been advised of this advertisement.

Address CA-1654,
care of "Mechanical Engineering."

NAVAL OFFICER

Mechanical engineer who has just been released, or expects to be released, by the Navy may find an opportunity with our company. Work will consist of some design, manufacturing, and estimating.

This is a small company that manufactures equipment for large steam boiler and chemical plants. Company has had a good growth record which would indicate an opportunity for advancement.

The man we want is a graduate engineer with good college record. His experience in the Navy and elsewhere should preferably be along mechanical lines. Age 25 to 35.

Stock Engineering Company
Cleveland, Ohio

sales engineer wanted for hydraulic presses and equipment

The sales division of an Eastern company has an opening for a thoroughly experienced man in the field of hydraulic presses, of both the accumulator operated and self-contained types, hydraulic machinery and hydraulic pumping equipment. Sound engineering background and a good sales personality are prime requisites. Salary open. Write giving outline of personal and business record. Interviews will be arranged at our expense for those who qualify. Letters acknowledged promptly and treated in confidence. Address:

Address CA-1624
Care of "Mechanical Engineering."

MECHANICAL ENGINEER

Major Oil Company requires graduate Mechanical Engineer for Production Department. Either experienced or inexperienced.

Address CA-1625, care of "Mechanical Engineering."

DESIGNER

of dies, tools, fixtures, and special machinery. Broad experience on sheet metal dies of all types essential. An excellent opportunity for a man interested in steady employment with a progressive company.

Reply by letter to Chief Production Engineer, giving age, experience, salary expected and personal data.

PERFECTION STOVE CO.
7609 Platt Ave.
Cleveland 4, Ohio

SALES SERVICE ENGINEER—with mechanical and chemical background of training and experience. Will find excellent opportunity to progress with us. We mine, manufacture and sell an essential material of wide and expanding use in all types of industry. Fair starting salary. Veteran preferred. Address CA-1493, care of "Mechanical Engineering."

ENGINEER—experienced in modern quick freezing methods and equipment as applied to food processing, with background in design and operation of large refrigerating systems, cold storage, and freezing plants. National Organization. Headquarters N. Y. C. Salary open. Address CA-1589, care of "Mechanical Engineering."

YOUNG ENGINEERS—two required, one familiar with design and operation of multiple effect evaporators, one familiar with design and operation of spray driers or allied drying operations. Salary $4200 to start. Location Wisconsin. Send full personnel details and experience including recent photo. Address CA-1600, care of "Mechanical Engineering."

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SALES ENGINEERS AND DESIGNERS WANTED: One experienced Boiler Sales Engineer and one experienced Heat Exchanger Sales Engineer, also one experienced Valve Sales Engineer for New York City Office. Apply Henry Vogt Machine Co., 80 Broad St., New York, N. Y. Also require Designing Engineers in Louisville for each of above departments—Address 10th and Ormsby Sts., Louisville, Ky.

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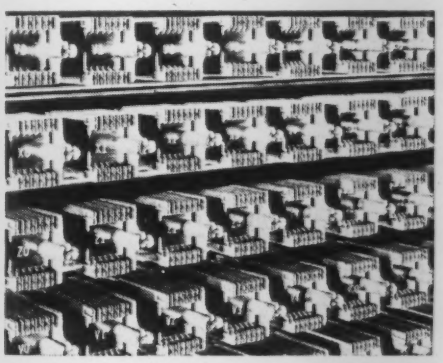

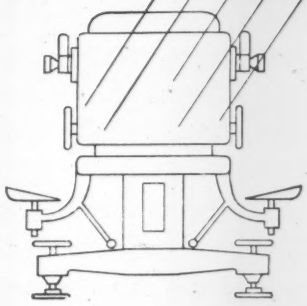

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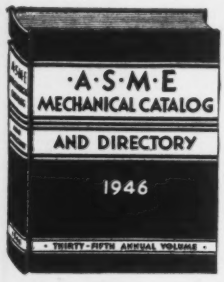

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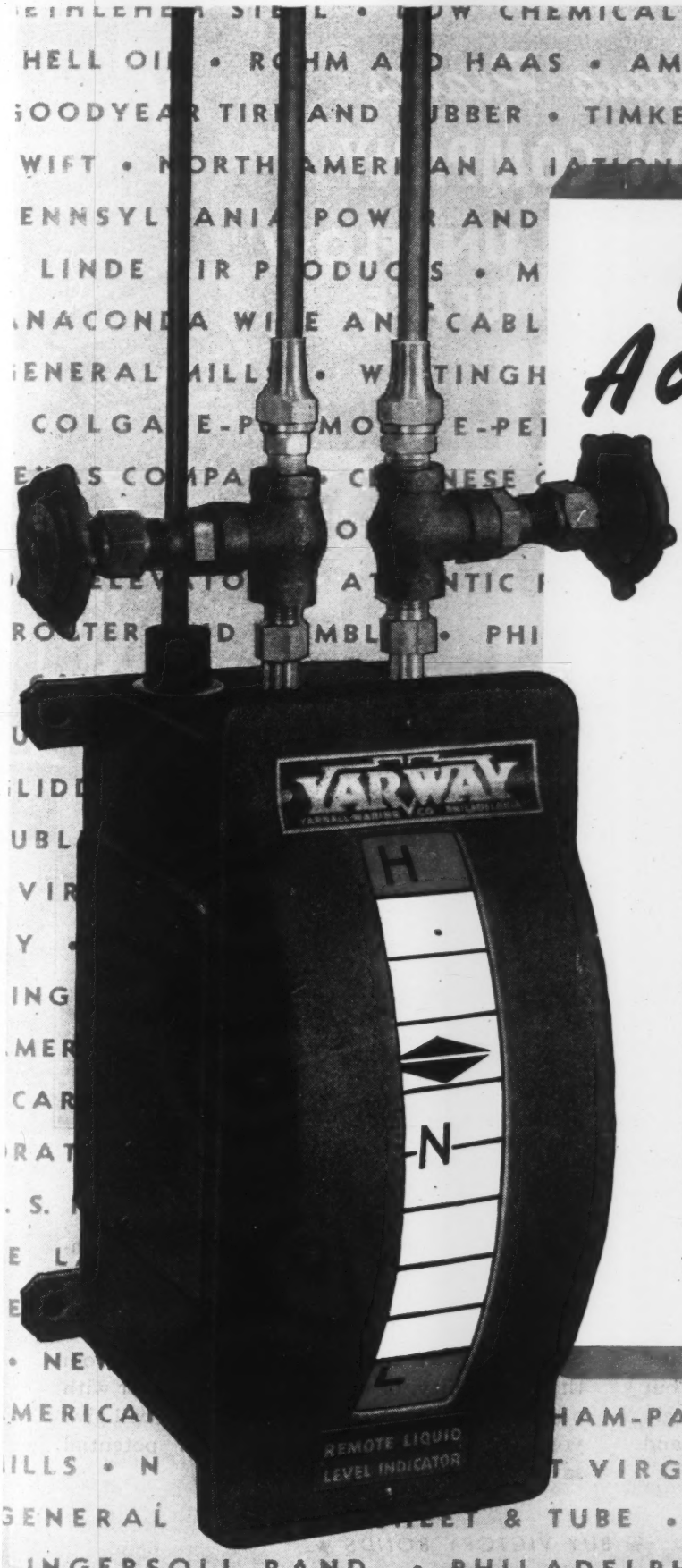

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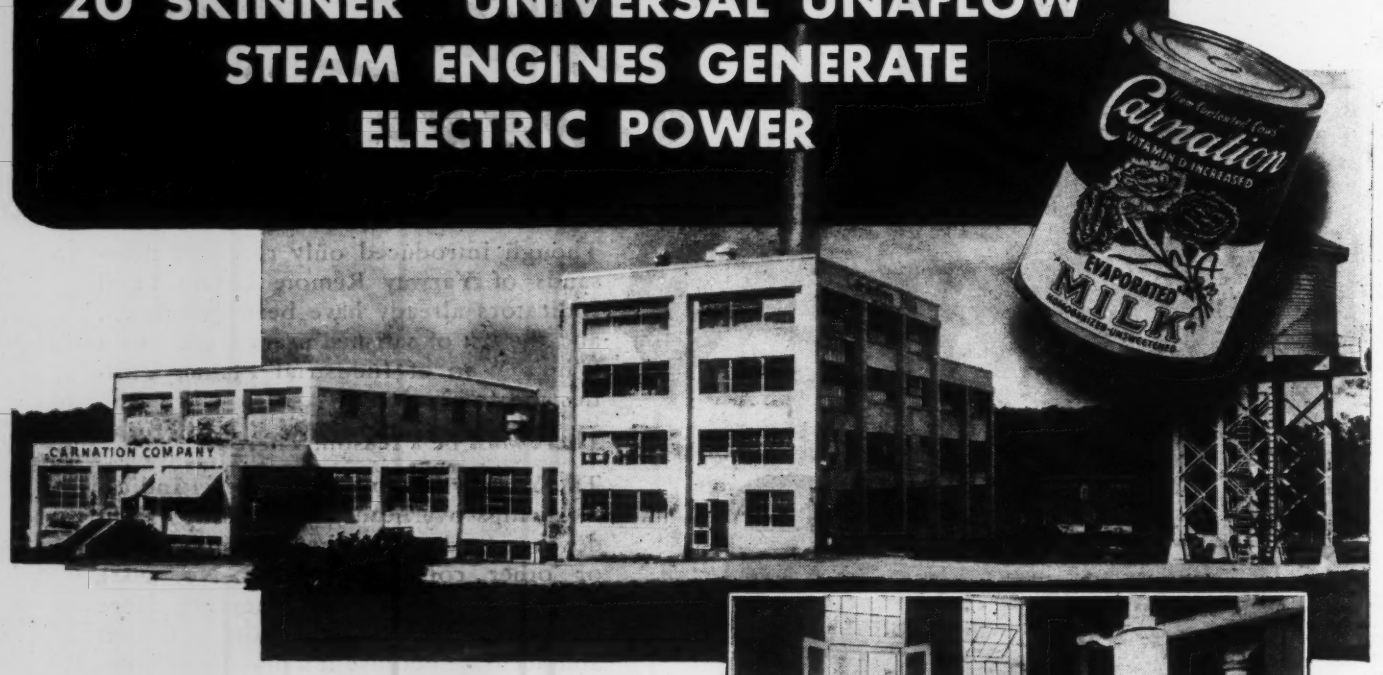

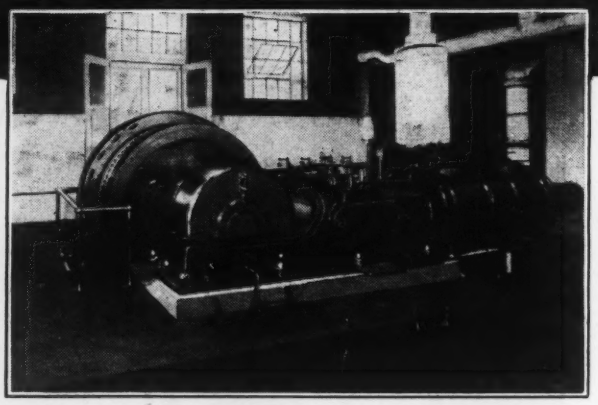

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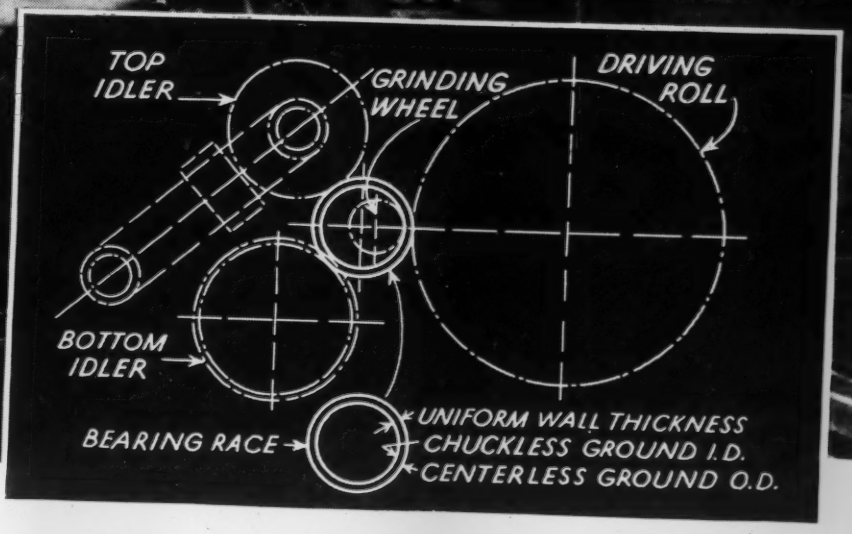

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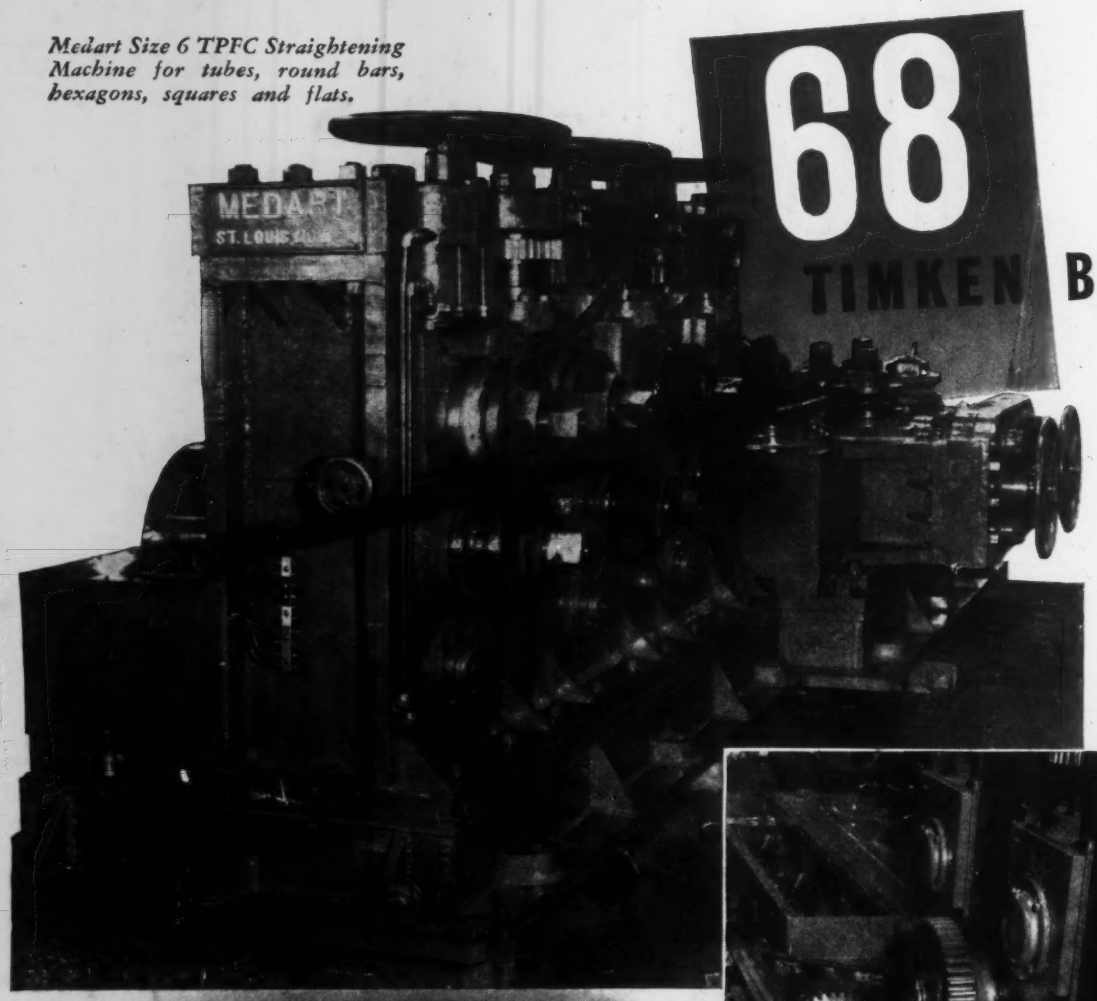
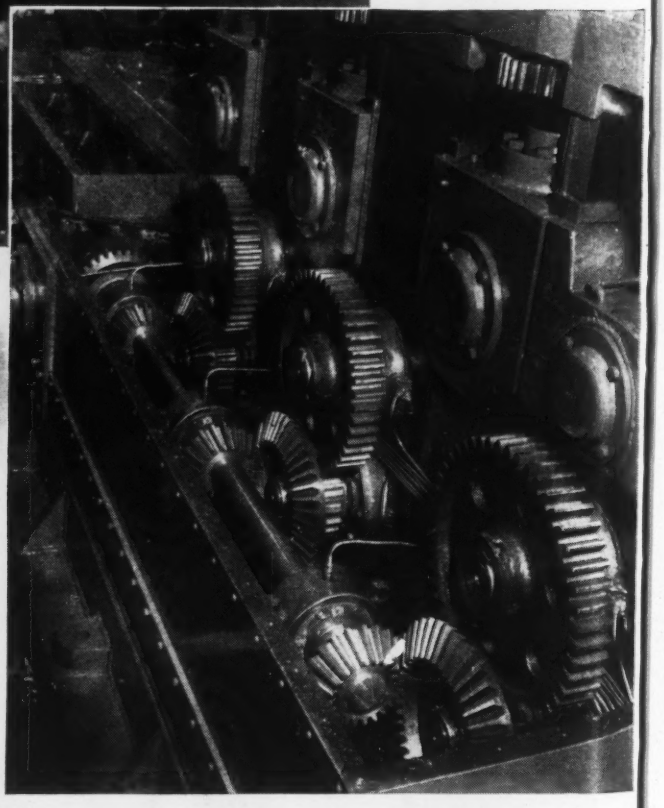


68 TIMKEN BEARINGS

IN THIS MEDART TPFC STRAIGHTENER



Rear end of straightener with gear cover removed, showing location of Timken Bearings.

This is a case where bearings must be able to perform with modern machine tool precision and rolling mill endurance.

Complete mastery of every operating requirement is assured by the use of Timken Tapered Roller Bearings; first, because Timken Bearings possess every essential qualification — friction elimination; radial-thrust load capacity; shock resistance; and ability to hold moving parts in correct and constant alignment; second, because enough Timken Bearings are used to afford full protection throughout the machine.

The Medart Company, St. Louis, uses Timken Bearings with similar effectiveness in various other types of steel mill equipment which they manufacture, also in pillow blocks, marine drives, etc. They have proved it pays. It will pay you, too.

Every Timken Bearing is positively identified by the trade-mark "TIMKEN" stamped on cup and cone. Make sure it appears on every bearing that goes in your equipment. The Timken Roller Bearing Company, Canton 6, Ohio.

TIMKEN
TAPERED ROLLER BEARINGS